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Draft Supplement

to the Environmental Impact Statement for an Amendment to the Pacific Northwest Regional Guide

Volume 2, Appendices

Spotted Owl Guidelines

DRAFT SUPPLEMENT
TO THE ENVIRONMENTAL IMPACT STATEMENT
FOR AN AMENDMENT TO THE PACIFIC NORTHWEST REGIONAL GUIDE

APPENDICES, VOLUME 2

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Appendix A

ISSUES AND CONCERNS

INTRODUCTION

The appeal to the Secretary of Agriculture was based on the treatment of the spotted owl issue in the Final Environmental Impact Statement for the Pacific Northwest Regional Guide. The appeal was sustained and the Deputy Assistant Secretary of Agriculture directed the Chief of the Forest Service to prepare a Supplement to the Final Environmental Impact Statement for the Regional Guide. The Supplement was to address the issue raised in the appeal, that is, the issue of spotted owls.

A number of people in the Pacific Northwest are intensly interested in the issues underlying the preparation of the Supplement. Those most concerned generally fall into one of two groups: those individuals and organizations that are conservationists or environmentalists and those individuals and organizations that are related to the wood products industry.

A consultant, Gerald Oncken of Northwest Executive Consultants, Inc., was hired to write a report on the public's perception of the spotted owl issue. In August of 1985, he interviewed people representing the conservation organizations and the industrial organizations. He found that the two groups perceive the issues differently and that each wants a different outcome from the Supplement. Following is a summary of the views of the two groups as told to Gerald Oncken.

The conservation groups stress that the real issue is management of old growth. There should be a discussion in the Supplement on old growth that includes forest inventories, historical perspectives, effects over time of harvesting old growth, old growth on private lands, and the effects of harvesting old growth on other resources and the environment in general. The conservationists want the Supplement to include a complete history of the plans for the management of spotted owl habitat along with all the recent information on the biology of the owl. They also want a discussion of a worst case scenario and an analysis of risk. Rather than focusing on mill capacity when discussing the economy, the conservationists want an analysis of the market trends for timber products.

The industrial groups also see an issue broader than the spotted owl. They believe that the owl is being used as a tool to block the cutting of old growth. Because of the uncertainty concerning the owls needs, they feel that old-growth stands should be managed. The industrial groups want all the possible impacts of the alternatives to be clearly understood. They are worried about the many mills that are geared to process old growth and fear the collapse of the industry if there are severe reductions in the allowable sale quantity. The possible loss of jobs is of major concern to

them. The industry wants no major reductions in the allowable sale quantity, consideration of an approach that would keep the old growth in the timber base, and the options kept open.

After reviewing the Secretary's letter, the Oncken report, and other correspondence with interested individuals and groups, the Interdisciplinary Team identified those issues and concerns which address the planning question, "How should the National Forests maintain viable populations of northern spotted owls?" The issues and concerns are listed as follows:

1. **The Spotted Owl Management Guidelines Have Been Challenges as Failing to Consider the Cumulative Impacts of Timber Harvesting on the Spotted Owl.**

   The Forest Service has been using the Interagency Spotted Owl Guidelines (5/79) as a basis for providing spotted owl habitat in the Pacific Northwest Region. The guidelines have been challenged as being "outdated" and in need of revision (1/85 reply of National Wildlife Federation to Chief's statement). In the appellants opinion the Regional Guide provides management guidance as well as planning direction on old-growth harvesting, and therefore, the environmental implications of old-growth harvesting should be addressed in the Environmental Impact Statement (EIS). The appellants feel the Interagency Guidelines are not functionally equivalent to an EIS. The appellants implicitely state the need for prudent management of old-growth forests.

   Two closely related topics to timber harvesting have been raised by some members of the public as they interpret the guidelines:

   A. Harvesting of old-growth forests in the Pacific Northwest has jeopardized spotted owl viability, may lead to extinction of the species, and will reduce management options for ensuring its viability (Lande 1985).

      The effect of future habitat alteration (conversion of old growth to managed stands) may cause extinction of northern spotted owl based on proportions of suitable habitat currently being occupied. Lande speculates that the spotted owl can probably not persist where less than 20 percent of an area is composed of suitable habitat since young owl adults have difficulty finding a mate, or may perish from starvation or predation.

   B. Timber stand management, which includes tree harvesting, is not conclusively accepted as a way to provide spotted owl habitat. Old-growth stands have functional and structural characteristics which may be difficult to duplicate by management, i.e., structural composition of snags and downed logs, nutrient cycling rates, multistoried canopies, a range in tree sizes, and uneven age structure.

This issue, as expressed by several members of the public, is closely tied to the kind of habitat preferred by northern spotted owls and whether this habitat can be satisfactorily managed for its structural characteristics or require dedication to preserve these characteristics.

The Society of American Foresters (SAF) position paper Scheduling the Harvest of Old Growth Timber (J. For. 1983) recommended a preservation form of old-growth management. The SAF task force felt there was no evidence or practical experience that shows old-growth conditions can be reproduced silviculturally.

The recently published habitat guidelines for western Oregon and Washington (Brown, Reade. 1985. Management of Wildlife and Fish Habitats in Forests of Western Oregon and Washington, Part 1. USDA Forest Service. Publ. No. R6 F&WL-192-1985. 332 p.) theorizes that silvicultural treatment of timber stands can be used to create suitable spotted owl nesting habitat. The guidelines explicitly recommend retaining natural old-growth stands without salvage until active stand management proves feasible.

2. **Current Management Guidelines in the Regional Guide Contain Information Gaps and Uncertainites Regarding the Probable Impacts of Timber Harvesting on Spotted Owls.**

Northern spotted owl management direction as stated in the Pacific Northwest Regional Guide is currently used by the National Forests to manage spotted owl habitat areas. Current information on the spotted owl collected by federal, state and private biologists suggests more habitat and greater owl populations than thought available in 1980. The appellants suggest spotted owl information available for the Regional Guide is not sufficiently detailed to assure maintenance of a viable owl population. Specific elements of concern are related to:

A. The size of suitable habitat. The Interagency guidelines provide for each owl pair that both a 300-acre core area and an additional 700 acres within 1.5 miles of nest be provided.

B. The distribution of suitable habitat. The distribution factor directly affects owl survival rates, habitat occupancy rates and maximum dispersal distances.

C. The number of breeding pairs necessary to assure viability. The distance between designated Spotted Owl Management Areas, suspected habitat occupancy rates, large variation in reproduction success among individual owls, and needs for adequate gene flow within a population raises a question whether 500 breeding pairs as proposed in the Regional Guide are adequate for viability (Lande 1985).

One of the purposes of this Supplement is to evaluate the available spotted owl research and to identify areas of knowledge requiring additional study.

3. **The Forest Service has not Considered the Worst Case Possibilities of Proceeding with its Current Harvesting Activities in the Face of Inadequate Knowledge.**

This issue was raised by the appellants as a result of discussion related to Issue Number 2.

The CEQ Regulations for implementing NEPA state that:

> 1502.2(b) If (1) the information relevant to adverse impacts is essential to a reasoned choice among alternatives and is not known and the overall costs of obtaining it are exorbitant or (2) the information relevant to adverse impacts is important to the decision and the means to obtain it are not known (e.g., the means for obtaining it are beyond the state of the art) the agency shall weigh the need for the action against the risk and severity of possible adverse impacts were the action to proceed in the face of uncertainty. If the agency proceeds, it shall include a worst case analysis and an indication of the probability or improbability of its occurence.

Preliminary indications from available literature and the availability of appropriate process models suggest the information required to make a reasonable choice between alternatives is known and/or the cost to acquire the information is not exorbitant.

4. **There are Economic and Social Implications Associated with Alternative Levels of Spotted Owl Habitat Protection.**

These implications are primarily related to the resulting level of timber harvest. They include:

A. Effects on regional timber supplies.

B. Changes in revenues to counties and the Treasury.

C. Effects on dependent communities and jobs.

D. Other community impacts.

This issue was mentioned in the USDA Decision (3/8/85) remanding the Regional Guide (p. 12). It was also considered by the Forest Industry Region Six Planning Policy Committee. The Committee quotes the Decision letter concerning this issue in its 4/17/85 letter to the Regional Forester (p.2).

5. **The Forest Service Must Minimize Impacts to Other Resource Management While Providing Protection of Spotted Owl Habitat.**

The USDA Decision (3/8/85) addressed this (p. 8):

> "If minimum management requirements (MMRs) are unnecessarily restrictive, they could significantly limit the "decision space"

> which should be available to line officers, could make plans vulnerable to successful legal challenge based on grounds that the range of alternatives is unnecessarily restrictive and could involve significant and unnecessary opportunity costs."

and (p. 12):

> ". . . In addition, minimum management requirements for both size and distribution of suitable habitat within the Region should be reviewed to assure that they are no more constraining than is necessary to maintain the continued viability of the spotted owl in the planning area (Region 6). . . ."

This issue has also been addressed by representatives of the timber industry. "... the problem to be resolved is to minimize the resource values foregone to assure that the species (spotted owl) not become qualified for threatened or endangered federal listing" (Hayward 1982).

6. There is Disagreement as to the Habitat Requirements of Northern Spotted Owls.

Empirical investigations and experience suggest northern spotted owls show a strong affinity to old-growth stand conditions (Forsman and Meslow 1985, Forsman et al. 1982). Whether this correlation is true or a result of sampling bias is a question being raised by some members of the public. Hayward (1982) states the basic problem is the habitat preferences of the spotted owl and "the contention that the spotted owl is dependent upon old-growth stands." Many of industry's concerns about the spotted owl relate to whether the owl needs or desires old growth (Bailey 1985).

Appendix B

ASSESSMENT METHODS FOR EVALUATING VIABILITY OF SPOTTED OWL POPULATIONS

INTRODUCTION

The viability analysis presented in this Supplement involved: (1) assessing empirical information on the biological and ecological attributes of spotted owls; (2) assessing factors, such as inbreeding, variability of birth and death rates, and occurrence of environmental catastrophes, that have the potential for causing local or global extinction; and (3) summarizing results of these assessments in terms of the probability of continued existence of spotted owl populations for each alternative. Steps involved in the process were:

1. Estimate the current and future amount and distribution of spotted owl habitat.

2. Estimate the capability of habitat to support spotted owls.

3. Investigate occupancy of habitats and isolation of populations.

4. Investigate the effects of random birth and death rates on owl populations.

5. Estimate the amount of genetic variability that will be retained in owl populations.

6. Estimate the likelihood that environmental catastrophes will have a significant effect on owl viability.

7. Estimate the overall probability of persistence.

These steps are discussed below.

ESTIMATE THE CURRENT AND FUTURE AMOUNT AND DISTRIBUTION OF SPOTTED OWL HABITAT

Description and Inventory of Habitat

The first step in developing the inventory of suitable spotted owl habitat was to describe the habitat characteristics. The ensuing description of habitat included forest cover types and the specific structural stages used by spotted owls in Washington and Oregon. Information on habitat is summarized in Table 3-2.

The description of habitat was used by each Forest as a starting point in developing both map and tabular inventories of suitable spotted owl habitat. These inventories were based on data bases developed for Forest planning and on timber cover type maps available from timber inventory. None of these sources contained information on specific features witehin the stands, therefore, suitable habitat was identified from general stand characteristics only. The cover type, stand age, and size class were the main criteria. Generally, National Forests classified areas as suitable if they fit the cover type criteria listed Figure 3-2 (See Chapter 3, page 3-4) and were identified as mature or overmature stands. Specific criteria were tailored to the situation on each Forest. Results of the inventory are presented in Table 3-11 (See Chapter 3, page 3-32) and are also on maps that are stored in planning records in the Pacific Northwest Regional Office.

Information was also collected on the amount of suitable habitat located on private lands, state lands in Oregon and Washington, tribal lands, and lands administered by the National Park Service and the Bureau of Land Management. Sources of this information are discussed in Chapter 3 and in the planning records maintained in the Regional Office. The inventory information is summarized in Table 3-5. An additional breakdown of suitable acres on individual National Parks follows.

Table B-1

Acres of Suitable Habitat on Individual National Parks

National Park or Monument	Acres of Suitable Habitat
Olympic	323,000
North Cascades	126,000
Mt. Rainier	31,000
Crater Lake	50,000
Oregon Caves	300

Prediction of Habitat

In order to estimate effects on spotted owls, for each alternative the future conditions of habitat on land under all ownerships were predicted. A number of assumptions was required to facilitate this prediction. An assumption was made that areas that had been established as designated habitat areas, through formal management or agency policies, on land managed by Federal agencies in Washington, Oregon, and northern California would remain available as suitable habitat through time. These areas included 79 sites of 300 acres each on lands administered by the BLM in western Oregon and 288 sites of 1000 acres each on lands administered by the Forest Service in northern California. It was also assumed that the total amount of suitable habitat in national parks and on lands reserved from timber harvest within the National Forest System would remain constant

over time. State lands, private lands, and tribal lands were not assumed to provide habitat in the future because no areas have been established as spotted owl habitat areas on those lands.

Non-reserved lands administered by the Forest Service in Washington and Oregon were the main variable in determining the future conditions of habitat under each of the alternatives. There were six steps to track the future of these lands.

1. Areas that would be established as spotted owl habitat areas were mapped on each Forest according to the standards and guidelines specified for the alternative.

2. The total number of spotted owl habitat areas that would be established on non-reserved lands was determined from these maps.

3. For alternatives that provided for more than the currently planned size, or number, or both, of habitat areas, a sampling procedure was used to determine if the specified number of acres could actually be achieved for the habitat areas. This sample provided an estimate of actual acres of suitable habitat that could be found within 7400 acres on the proposed locations of habitat areas. The 7400 acre figure represents the mean home range area per pair of owls (See Table B-12).

4. Information from steps 2 and 3 above was used to determine the mix of acres that would be included in habitat areas on each forest under each alternative. This mix of acres included:

    a. A fraction of the total acres that are suitable for owl habitat, but unsuitable for timber production.

    b. The number of acres that are suitable both as owl habitat and for commercial timber harvest.

    c. The number of acres in younger age classes that will eventually become suitable. These acres, termed capable habitat, were added to habitat areas when the sampling described in step 3 above showed that there were inadequate suitable acres to meet the objective of the alternative.

5. The acres in steps 4b and 4c above were subtracted from the acres suitable for timber production. The FORPLAN model for each Forest was then used to project the rate of harvest of habitat not included in the designated habitat areas.

6. In those cases in which habitat areas were composed of a mix of capable and suitable habitat, the rate of succession of capable habitat to suitable habitat was estimated by determining the age class of the capable habitat and projecting the age at which it would become suitable. This information thus obtained was used to make a prediction of increases in suitable habitat within habitat areas over time. For the purposes of this prediction, habitat was assumed to become suitable when it reached 200 years old.

When these projections were completed, an additional adjustment was made to account for the fragmentation of habitat outside of habitat areas. A series of habitat fragmentation indices were used to estimate the fraction of suitable habitat that would occur in acreages large enough to be used by owls. In order to develop the indices, the occurrence of suitable habitat was sampled within circles with a 2-1/8-mile radius. The circles were selected at random on National Forest maps of suitable spotted owl habitat. A circle with a radius of 2-1/8 is about 9000 acres. This number of acres is approximately the largest home range for either a single owl or a pair of owls that has been observed in typical habitat conditions (Brewer and Allen, 1985). The statistic recorded in this sampling was the acreage of suitable habitat present in each of the 2-1/8-mile radius areas. National Forests were placed into three strata for this sample, based on the amount of suitable owl habitat remaining in their inventories. The strata were: (1) National Forests with greater than 40 percent of their inventory remaining in suitable spotted owl habitat; (2) National Forests with 25 to 40 percent of their inventory in suitable habitat; and (3) National Forests with less than 25 percent of their inventory in suitable habitat. A separate index was developed for each stratum. The index was calcuated from the following two pieces of information:

1. The fraction of suitable acres that totaled at least 300 acres within the 2-1/8-mile-radius circle. Circles with less than 300 acres of suitable habitat were not included in the calculation.

2. The mean acreage of suitable habitat within the 2-1/8-mile-radius circles, excluding those circles with less than 300 acres.

Table B-2

Index of Suitable Habitat

Percent of Inventory Remaining in Suitable Habitat	Percent of Suitable Acres With at Least 300 Acres Within a 2-1/8-Mile-Radius Circle	Mean Suitable Acres Within a 2-1/8-Mile-Radius Circle
0-25%	86	795
26-40%	94	3165
>40%	100	3497

This information on fragmentation was applied to projected future inventory in order to estimate the percent of suitable habitat that would be usable by owls. The same process was used to determine the mean amount of habitat that would be available within a 2-1/8-mile-radius circle. The index that was used for each National Forest at each future point in time was determined by the percent of that National Forest's inventory remaining as suitable habitat.

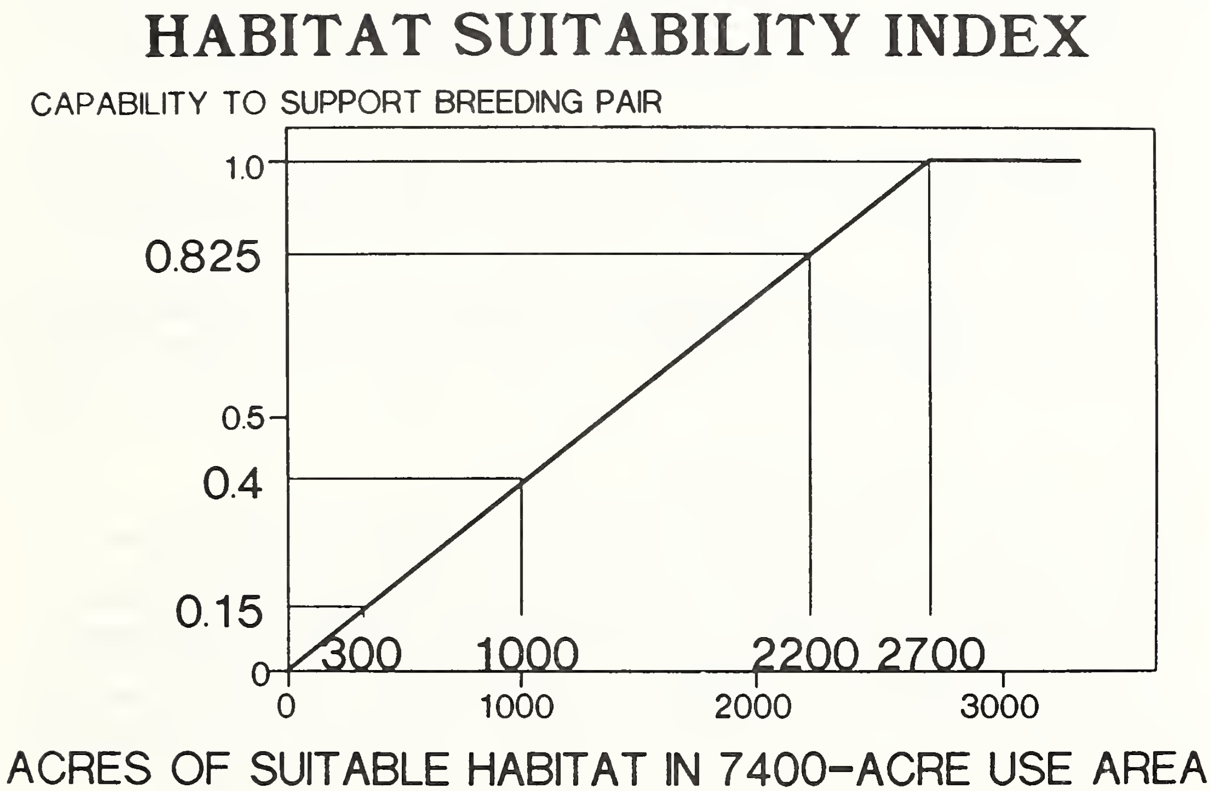

Figure B-1. Habitat Capability Index Relating Acres of Suitable Habitat in a 7400-acre Area to Capability to Support a Breeding Pair of Owls

To summarize, the prediction of habitats in different ownerships was handled in the following ways:

1. No future habitat was predicted for state, private or tribal lands.

2. The total amount of suitable habitat in national parks, wildernesses, and other Federal lands that are reserved from timber harvest was predicted to remain constant over time.

3. Other Federal lands formally established as designated habitat areas were predicted to remain available as suitable habitat through time. This included 79 sites administered by the Bureau of Land Management in western Oregon and 288 sites administered by the Forest Service in northern California.

4. For each of the National Forests in Oregon and Washington, designated habitats for spotted owls specified by each alternative were mapped and the total acreage of suitable habitat in those areas was predicted through time.

5. The FORPLAN model for each National Forest in Oregon and Washington was used to project the harvest rate of suitable habitat outside of habitat management areas.

Summary by Physiographic Provinces

The current tabulation and future projection of suitable habitat was summarized within physiographic provinces as they are classified by Franklin and Dyrness (1973) and were modified for use in this project. Provinces were used because the points at which subpopulations of owls could become isolated in the future coincided well with province boundaries. Five general provinces were considered: the Olympic Peninsula, the Washington Cascades (a composite of the Northern Cascades, Southern Washington Cascades, and the western fringe of the Okanogan Highlands), the Oregon Cascades (a composite of the Western Cascades and the High Cascades), the Klamath Mountains (which included southwestern Oregon and northwestern California), and the Oregon Coast Range.

ESTIMATE CAPABILITY OF HABITAT TO SUPPORT SPOTTED OWLS

Determining Habitat Needed to Support Owl Pairs

Capability to support pairs was based on the percent of the projected habitat areas that could actually support a pair of owls. Capability is a function of stand structure, habitat fragmentation, and total area of suitable habitat within an average use area, that is, the size of the home range. Stand structure and the assessment of habitat fragmentation were described in the step above. To assess the effect of habitat area, we calculated an "area habitat suitability index" (area HSI) describing the probability that a site is capable of supporting a pair of owls, given that the site has a particular acreage of suitable habitat within a home range area. Refer to Figure B-1.

The area HSI was derived from a modification of the standard Bayes formula for conditional probabilities (e.g., Levin and Kirkpatrick, 1975). The index was calculated from: (a) the conditional probability of a site having a particular habitat area, given that it is occupied by a pair of spotted owls; divided by (b) the probability of randomly selected sites having a particular habitat area, regardless of the status of occupancy. Parameter (a) was estimated by measuring on the Forest Service maps the total acres of suitable owl habitat that were within 1-1/2-mile-radius circles, centered on known occupied sites. Parameter (b) was estimated by measuring the total acres of suitable owl habitat that were within a 1-1/2-mile-radius circle centered on randomly selected designated or potential spotted owl habitat areas. The result of dividing parameter (a) by parameter (b) is the probability that a site will be occupied by a pair of owls, given that it contains a specified acreage of suitable habitat within the sampled 1-1/2 mile radius area.

The results of these calculations are to be used for comparison purposes because the sampling of suitable habitat within a given radius is not an adequate measure of either the size or shape of pair's home range or of the acreage of suitable habitat being used by the pair. To reflect this fact, the results of the calculation were expressed in terms of the proportion of suitable habitat contained within the sampled areas rather than the absolute acreage of suitable habitat. The resulting formula for predicting the probability of occupancy from proportion of suitable habitat was:

$$P(O) = .045 + 2.6 \times PS$$

where P(O) = probability of occupancy by a pair of owls
and PS = the proportion of suitable habitat in the sampled area

To make the most realistic use of this area HSI in the analysis, it had to be expressed in terms of actual acres of suitable habitat. Values of the actual acreage were calculated by multiplying the proportions of suitable habitat in the sample area by 7400 acres, which is the mean use area of pairs of owls in Oregon and Washington (see Chapter 3). The resulting HSI, expressed in terms of acres, was:

$$P(O) = .046 + .000354 \times AS$$

where P(O) = probability of occupancy by a pair of owls
and AS = the acres of suitable habitat within a 7400-acre use area

Results of this HSI for selected acreages of suitable habitat are shown in Table B-3.

The figure of 2700 acres of suitable habitat, which has an HSI value of 1, is relatively close to the mean acres of suitable habitat found within home ranges of telemetered pairs of owls in Oregon and Washington. This included 6 pairs in Oregon with home ranges having a mean of 2264 acres of suitable habitat and 3 pairs in Washington with home ranges containing a mean of 4202 acres of suitable habitat (See Chapter 3). The mean of these figures is 2910 acres of habitat.

The HSI is also reasonably consistent with Forsman's figure of 93 percent,

Table B-3

HSI for Selected Acres of Suitable Habitat

Acres of Suitable Habitat in a 7400-acre Use Area	Probability of Occupancy by a Pair of Owls
300	0.15
500	0.22
1000	0.40
1500	0.58
2000	0.75
2200	0.82
2700	1.0

the percentage of occupied sites in Oregon he found in mature and old-growth forests (see Appendix C). For these reasons, the HSI was accepted as a tool to estimate relative likelihoods that areas containing different amounts of suitable habitat would be occupied. However, the HSI must be used with caution because it is based solely on map measurements rather than on field data of actual use of habitat by owls. It should also be recognized that the HSI is based only on gross acres of suitable habitat and does not differentiate the relative quality of sites.

Estimating the Capability of Reserved Lands and Lands Unsuitable for Timber Production to Support Owls

The potential capability of reserved lands, administered by the Forest Service in Oregon and Washington, to support pairs of owls was estimated based on National Forest maps of suitable habitat in those reserved areas. The procedure used was as follows:

1. Potential home range areas of owl pairs in reserved areas were located on National Forest maps. These potential home range areas were represented by circles with radii of 2-1/8 miles drawn to enclose suitable habitat. These circles were fitted into the reserved areas so that the largest number of potential home range areas, each having at least 300 acres of suitable habitat, were drawn.

2. The total number of potential home range areas in reserved lands, along with the suitable acres in each of these areas, were tabulated for each National Forest.

3. Mean suitable acres were determined for the areas on each National Forest and the HSI that corresponded to that acreage was determined.

4. For each National Forest, the number of areas was multiplied by the appropriate HSI value to determine the number of potential pairs that the reserved lands could support.

Results are shown, by National Forest in Table B-4. These capabilities were treated as constants across all alternatives.

Table B-4

Capability of Reserved Lands to Support Owls by National Forest

National Forest	Number of Potential Home Range Areas	Mean Suitable Acres per Potential Home Range Area	Potential Number of Pairs
Deschutes	1	2250	1
Gifford Pinchot	24	2345	21
Mt. Baker-Snoq.	75	2054	58
Mt. Hood	25	3750	25
Okanogan	1	2250	1
Olympic	11	3660	11
Rogue River	12	1833	8
Siskiyou	21	2292	18
Siuslaw	3	1916	2
Umpqua	10	2245	8
Wenatchee	39	1685	25
Willamette	33	2542	31
Winema	6	941	2

A similar procedure was followed for lands unsuited for timber production. Most of the suitable habitat found on these lands was in small acreages that were of an insufficient size to support pairs of owls. These numbers were also treated as constants across all alternatives. Only three National Forests had areas mapped that were large enough to support pairs of owls entirely on lands unsuited for timber production. Refer to Table B-5.

Table B-5

Capability of Lands Unsuited for Timber Production to Support Owls, by National Forest

National Forest	Number of Potential Home Range Areas	Mean Suitable Acres per Potential Home Range Area	Potential Number of Pairs
Mt. Baker-Snoqualmie	4	1183	2
Mt. Hood	13	1570	8
Willamette	13	1641	8

Estimating the Capability of Designated Spotted Owl Habitats, Outside of Reserved Lands, to Support Spotted Owls

The procedure used to determine the number of designated habitat areas, along with their suitable habitat acres, over time was outlined in the section on "Habitat Projection." This procedure provided numbers and acres of habitat areas for each National Forest under each alternative. It also gave the rate of increase of suitable habitat acres over time if the designated habitat areas started out with fewer suitable acres than specified in the alternative.

To translate these figures into capability for supporting owl pairs, the appropriate HSI value was determined for the mean acreage of suitable habitat per habitat area on the Forest. This HSI was then multiplied by the number of areas to determine the potential number of pairs that could be supported. For example, if there were 100 areas containing a mean of 2200 acres of suitable habitat, the number of pairs potentially supported was calculated as:

$$100 \text{ areas} \times .82 = 82 \text{ pairs}$$

where 0.82 is the HSI value associated with 2200 acres.

Estimating Capability of Lands Suitable for Timber Production to Support Pairs of Owls

This is the category of suitable habitat that would be depleted over time because of timber harvest. Procedures for predicting the numbers of these acres and correcting them for fragmentation were detailed in the section on "Habitat Prediction". Capability was estimated by taking the acres of remaining suitable habitat, multiplying by the proportion expected to be useable by pairs of owls, dividing this figure by the mean suitable habitat acres expected to be available to a pair, and multiplying the result by the appropriate HSI value. See the table in the "Habitat Projection" section for the appropriate figures.

As an example, if a National Forest had 25,000 acres of suitable habitat remaining outside designated habitat areas, and this represented less than 25 percent of the total commercial forest area, the capability to support pairs would be calculated as:

25,000 X 0.86 = 21,500 acres expected to be useable by pairs
21,500/795 = 27 home range areas containing a mean of 795 acres
27 X 0.33 = 9 pairs that could potentially be supported

where 0.86 is the proportion of suitable habitat that is expected to occur in a density of at least 300 acres within 9000 acres, 795 acres is the mean amount of suitable habitat that is expected to occur within a 9000-acre use area, and 0.33 is the HSI value for 795 acres of suitable habitat.

These calculations were made for each National Forest in each of the projected time periods out to 150 years in the future.

Estimating Capability of Lands, Administered by other Agencies to Support Pairs of Owls

Assumptions made in predicting habitat on land managed by other Federal agencies were in the "Habitat Prediction" section. A further series of assumptions was needed to translate predictions of habitat into the capability of these other lands to support owl pairs.

On lands administered by the Bureau of Land and by the Pacific Southwest Region of the Forest Service, actual spotted owl habitat areas have been designated. The capability of these areas to support pairs of owls was estimated by multiplying the number of areas by the reported current occupancy rate of those areas by pairs of owls. The reported occupancy rate of areas by pairs on the Forest Service areas is 0.68. Occupancy for the Bureau of Land Management sites was derived from data gathered by the Oregon Department of Fish and Wildlife. The resulting occupancy figure is 0.72. Details of the derivation are available in the Planning Records kept in the Regional Office. Accordingly, the potential capability to support pairs of owls was estimated as shown in Table B-6.

Table B-6

Capability of Lands Administered by the Bureau of Land Management and the USDA Forest Service, Pacific Southwest Region, to Support Owls

Agency	Number of Habitat Areas	Estimated Potential Number of Owl Pairs
Pacific Southwest Region, Forest Service	288	195
Bureau of Land Management	79	56

Lands administered by the National Park Service have no designated spotted owl habitat areas because none of the suitable acres of habitat are proposed for timber management. Therefore, a different assumption was needed to estimate the capability to support owl pairs. In this case, information was available on the total acres of suitable habitat. There was, however,no data on fragmentation of this habitat. To account for any potential effects of fragmentation, capability was calculated by dividing the total acres of suitable habitat by the mean home range sizes observed for telemetered pairs of owls. This figure was 8568 in Washington and 6614 in Oregon. Resulting capabilities for each of the parks are presented in Table B-7.

Capabilities of lands administered by the Bureau of Land Management, the National Park Service, and the Pacific Southwest Region of the USDA Forest

Table B-7

Capability of National Park Service Land to Support Owls

National Park Service Land	Acres of Suitable Habitat	Potential Number of Owl Pairs
Olympic	323,000	37
North Cascades	126,000	14
Mt. Rainier	31,000	3
Crater Lake	50,000	7
Oregon Caves	300	0

Service to support pairs of owls were treated as constants across alternatives and across time.

Summarizing the Capability to Support Pairs of Owls

Capability of all lands to support owls, as described previously, was summed within physiographic provinces for each time period and each alternative. These capability figures were later used as the basis for the initial population estimates used in the demographic modeling. The modeling is described in a later section.

INVESTIGATE HABITAT OCCUPANCY AND POPULATION ISOLATION

The Dispersal and Habitat Occupancy Model

To help investigate habitat occupancy and population isolation, a simulation model of owl dispersal was used. The objectives were to estimate: (1) the percentage of suitable habitats that would likely be occupied over time by a breeding pair of spotted owls; and (2) the spatial distribution of occupancy under each planning alternative and at specified points in time. The method was to apply empirical information and theoretical models of dispersal dynamics and habitat occupancy to the estimated distribution and abundance of suitable owl habitat

The simulation model represented locations of spotted owl habitat areas throughout the range of the northern race by the coordinate points of latitude-longitude. The mapped locations of spotted owl habitat areas were used to develop the data base for analysis of each management alternative.

In the model, owls dispersed among and bred within habitat areas at rates according to empirical demographic data. The model kept track of the numbers of owls within three age classes (juvenile, subadult, and adult) and the yearly use of each habitat area over a simulated 150-year period of time.

The model used functions for dispersal distances and directions. It also used information and assumptions on strategies of spotted owls to search for habitat and mates. The model estimated the percentage (and total number) of habitat areas that are likely to be occupied over a given period of simulated time. The model also showed the structure of the simulated spotted owl population, that is, the numbers of adults, juveniles, males, and females.

Model Parameters and Functions

Parameters that served as input to the simulation were:

1. The annual rate of adult mortality.

2. The annual rate of subadult mortality.

3. The average annual number of fledglings produced per nest.

4. The juvenile mortality during the post-fledging, predispersal period.

5. The maximum distance travelled by dispersing juveniles and the amount of area searched.

A sixth parameter was added after initially testing the model. This was the maximum distance for a single subadult to search for a mate, just prior to its first breeding season.

Adult mortality was set equal to 15 percent per year. This is the same rate used by Barrowclough and Coats (1985), based on field observations reported by Forsman and others (1984) and Gutierrez and others (1985). Subadult mortality was assumed to be equal to the adult mortality rate.

The number of young fledged was set to an average of 55 (including both sexes) per 100 pairs, but was allowed to fluctuate between years. This number was derived from observation of 327 nests during the period 1972 through 1985 in Oregon and California (Laymon and Barrett, 1985; Gutierrez and others, 1985; Barrows, 1985; Forsman and others, 1984; Meslow, 1984a and 1984b). Each adult pair was assigned zero, one, or two fledglings, as an independent event. The probability of a given pair producing zero young was set to 67 percent; the probability of producing one fledgling was 13 percent; and the probability of producing two fledglings was 20 percent (from observations of 215 nests, averaging 55 fledglings per 100 nests, by Forsman and others, 1984; Gutierrez and others, 1985).

Estimates of juvenile mortality during the post-fledging, predispersal period (roughly July through September) average 38 percent (based on 141 observations from Forsman and others, 1984; Miller and Meslow, 1985; Laymon, 1985; Gutierrez and others, 1985; Gutierrez, 1985; and Meslow, 1984a and 1984b) and this value was used during the initial model runs. However, it appears that the number of young produced per nest includes observations made during the post-fledging, predispersal period.

Mortality rates were reported for only a portion of observed fledglings, whose fate was known. Therefore, the estimate of juvenile production may include broods where the post-fledging, predispersal mortality had already occurred. Thus, use of the 38 percent-rate may result in an over-estimate of juvenile mortality during this period. Sensitivity tests were done on this rate as part of the calibration of the model. These tests are reported in a later section.

Data reported by Miller and Meslow (1985) were used to determine dispersal distances of juveniles. The maximum distance traveled by individual juveniles, defined as the distance, in a straight line, between the natal area and the farthest point reached by the juvenile, ranged from 3 to 62 miles, with an average of 27 miles and a median of 23.5 miles. A frequency distribution was developed using the cumulative percent of observations for each recorded maximum distance. This approximated a linear distribution ($r^2 = 0.95$ with 26 degrees of freedom), where distance = frequency / (1.911). For each dispersing juvenile, a random number (frequency) was chosen, which was used to set the maximum distance traveled during that individual's dispersal.

Gutierrez (1985) described the pattern of juvenile dispersal as generally uni-directional, with the selection of direction apparently being random. In the simulation model, a quadrant, that is, northeast, southeast, southwest, or northwest, was selected randomly for each dispersal attempt. With the longer dispersal distances, a quadrant includes very large search areas (415 square miles at 23 mile radius, 1017 square miles at 36 mile radius, 1885 square miles at 49 mile radius), and does not accurately represent the observed dispersal patterns. The model included a function to restrict the amount of area searched by birds travelling farther than the median distance of 23.5 miles, such that the area searched increases at a linear rate rather than exponentially. Thus, 78 percent of habitats in the selected quadrant at a distance of 30 miles are findable; 59 percent of habitats at a distance of 40 miles are findable; and 47 percent of habitats at a distance of 50 miles are findable.

Additional Assumptions in the Model

The age of first breeding is assumed to be at the beginning of the third year.

Fledglings are assigned randomly to pairs, without attempting to control for habitat quality. Every location with pairs has an equal probability of producing young.

The mortality of adults, subadults, and juveniles in the post-fledging predispersal stage is assigned randomly.

Dispersal direction of juveniles is selected randomly.

Subadult birds are assumed to actively seek a mate prior to their first breeding season. Because, however, no field data are available to indicate the distances the traveled by subadults, separate runs were completed using

maximum distances of 12 and 27 miles. The rationale for this is that 80 percent of all juveniles observed by Miller and Meslow (1985) traveled at least 12 miles, with an average distance of 27 miles. In the model, subadults search for a mate in all directions; if none is available, the subadult does not move. Implicit in this search pattern is the assumption that subadults receive cues allowing them to always locate a mate at these distances, if one is available.

During each simulation, vegetative conditions were static. All habitat areas are fully suitable for spotted owls.

Data Base Development

For each spotted owl habitat area mapped by the National Forests, the location (latitude and longitude, in decimal degrees) and status of occupancy were recorded in the data base used to generate alternatives for model runs.

A number of the habitat areas were coded as having unknown occupancy by the Forests. These were randomly initialized as 50 percent occupied by pairs, 15 percent occupied by single adults, and 35 percent unoccupied to account for situations where owls were assumed to be present but did not respond to inventory efforts. In a similar fashion, habitats reported to be occupied by single birds were randomly initialized as 50 percent occupied by pairs and 50 percent occupied by single birds. Sex of single birds was assigned randomly. The relative proportions of pairs, single birds, and unoccupied habitat areas were based on the structure of the spotted owl population estimated in northwestern California (A. Franklin, personal communication).

Habitat occupancy on lands administered by the Bureau of Land Management were considered to be unknown and were initialized as described above. Habitat areas identified by the National Park Service were all coded as occupied by pairs.

Model Calibration

The initial simulation runs were done using the following demographic parameters: fledging rate of 55 young per 100 pairs; adult and subadult mortality rate of 15 percent; juvenile post-fledging, predispersal mortality rate of 38 percent; and no movement of subadults seeking a mate. Using a data base representing 1000 habitat areas in the Pacific Northwest Region, 79 habitat areas on Bureau of Land Management lands and 35 habitat areas in National Parks, the population exhibited very low occupancy by pairs and declined rapidly, with extinction occurring between 25 and 59 years. Analysis of standard life table also indicated that the population with these parameters would not persist.

The population crash predicted by the model does not match recently observed trends in the population. Possible explanations for the differences between model predictions and the actual trends in population size are discussed in the section on demographics. After reviewing the

results of these first runs, the model was recalibrated to simulate a more or less stable population under current habitat conditions. This would provide a reasonable approximation of observed trends in population size. The model was also modified to allow each unpaired subadult to actively seek a mate prior to its first breeding season, searching up to a specified distance from where it had settled following dispersal. This change was made because the model had predicted an unreasonably low percentage of pairs relative to the total number of adults.

Recalibration of the model was done by simulating the conditions of all the current habitat and then by varying the input parameters to reach a point of population stability under these conditions. This trend more closely matches the observed change in the spotted owl population over the last ten years (see the following section on demography).

The Oregon Department of Fish and Wildlife (ODFW) estimates that there are 1000 to 1200 pairs of spotted owls in Oregon. Considering that not all available habitat areas are occupied by pairs at any given time, about 1600 habitat areas would represent the current situation. For the calibration, we used only the land area within the Oregon Cascades physiographic province, which is roughly between latitudes 41.95 and 45.68 and longitudes 121.40 and 123.33. The current inventory of habitat was simulated by placing additional spotted owl habitat areas between the 478 mapped areas, to create an inventory of about 1100 habitat areas within this physiographic province. The initial overall rate of occupancy by pairs was set equal to 61 percent.

Using a distance of 12 miles for subadults to search for a mate, the population appeared to stabilize with a juvenile post-fledging, pre-dispersal mortality rate of about 23 percent. However, the population also exhibited little or no juvenile dispersal mortality. This could be because, with pair occupancy averaging 54 to 66 percent, vacant habitat was always available to juveniles, or because no surplus juveniles were being produced.

Because of the uncertainty surrounding juvenile post-fledging, predispersal mortality, the rate was then set equal to the adult and subadult mortality rates of 15 percent as a base rate to which dispersal mortality would be added. (It should be noted that juveniles actually would be expected to experience somewhat higher mortality because of their inexperience in finding and capturing prey.) When the model was run using 12 miles as the distance that subadults would search for a mate, the population increased, then stabilized at an occupancy rate for pairs of about 72 percent. Mortality of dispersing juveniles averaged 12 percent.

In the absence of empirical data on subadult patterns of movement, the calibration was also run using 27 miles as the distance a subadult would search for a mate. This distance is equal to the average distance travelled by dispersing juveniles and should be sufficiently large to eliminate any possibility that this parameter would be the limiting factor when comparing the proposed alternatives. As expected, the population increased, to stabilize at an occupancy rate for pairs of 73 percent. Mortality for dispersing juveniles averaged 2 percent.

Analysis of Alternatives

For each alternative, the simulation was run at least three times using the same input parameters. Each simulation predicted the number of adults and subadults in the population at given points in time, as well as the rate of occupancy of each habitat area by spotted owls.

The initial calibration parameters of 23 percent juvenile post-fledging, pre-dispersal mortality and 12-mile subadult search radius produced a stable population. A simulation for each alternative was also run using a 15 percent-juvenile post-fledging, predispersal mortality and 12-mile subadult search radius and a 23 percent-juvenile mortality and 27-mile subadult search radius. In addition, three of the alternatives were run using a predispersal mortality of 15 percent and a subadult mate-search distance of 27 miles.

Table B-8 shows the results using post-fledging, predispersal mortality of

Table B-8

Predicted Rate of Occupancy of Habitat
by Spotted Owl Pairs Under Various Alternatives
Using a Juvenile Post-Fledging, Predispersal Mortality Rate of 15 Percent
and
a 12-Mile Subadult-Search Radius

		Year				
Alternative(s)	State	0	15	50	100	150
C	WA	70	31	16	0	0
	OR	62	36	25	16	3
D,F,G,H	WA	66	45	33	17	1
	OR	62	40	29	23	15
E	WA	62	47	28	13	8
	OR	63	48	41	35	29
I	WA	57	37	23	16	3
	OR	63	43	31	11	2
J,K	WA	62	43	40	37	36
	OR	63	53	49	46	43
L (Only a portion of the data set was used. See text on calibration.)	OR	63	71	73	74	73

15 percent and the 12-mile distance that subadults searched for habitats in Oregon and in Washington. These model results were used as one of the parameters in the overall rule-set for determining probability of persistence. Results were also used as one of the indicators of isolation of populations, as discussed further in this document.

Note that this model reflected only the distribution of habitat areas and not size or quality of habitat areas. As a result, a single set of model outcomes is attributed to all alternatives that share the same habitat area distribution regardless of the differing size of habitat areas specified for those alternatives.

Each simulation was also run using the minimum number of habitats to be managed for spotted owls under each alternative. The amount of habitat was held constant with no adjustments for the period during which the amount of habitat would be reduced to that minimum level.

Isolation of Populations

Results of the dispersal simulation suggest that, under all alternatives, owls on the Olympic Peninsula are an isolated subpopulation. This finding was supported by plotting the locations of suitable owl habitats on state-wide maps and comparing the distances separating habitats to the observed capabilities of juveniles to disperse.

LIFE HISTORY INFORMATION

The initial step in the analysis of the effect of birth and death rates on viability was to compile scientific information on spotted owl distributional range and habitat use, life history characteristics, demography, and home range size. Range, habitat, and life history characteristics are discussed in Appendix C.

Demography

Demographic attributes of spotted owls are poorly understood. Barrowclough and Coats (1985) made the first attempt at describing a life table for spotted owls and acknowledged the paucity of hard information. The Forest Service effort in producing this Supplement has updated their demographic analysis by including pertinent results of spotted owl studies through 1985. The synthesis of these studies follows.

The estimation of the average reproductive rate is 0.55 young per pair per year (Table B-9). Considerable variation, however, in reproductive effort and success has been observed among various years and throughout the range of, at least, the northern race.

Spotted owls generally do not breed until the third year of life, although two-year-old birds have occasionally been observed nesting (Barrows, 1985; Miller and others, 1985). The average life span of spotted owls in the wild is unknown, but ten years is not an unreasonable estimate

(Barrowclough and Coats, 1985; E. Forsman, personal communication). Little is known of survivorship rates of spotted owls. There are no reported data on or estimates of mortality rates of spotted owl eggs, hatchlings, or nestlings. Observations of young owls at the nest sites suggest an overall predispersal mortality rate of 40 percent per year (Table B-10). A synthesis of the literature suggests a dispersal mortality rate of about 80 percent per year (Table B-11). Thus, first-year survivorship may be estimated as (1 - 0.40)(1 - 0.80) = 0.12. At the time of this writing, the 0.12 value updates an earlier estimate of 0.20 which is used in the life table analysis (Table B-13). Results as discussed below, however, remain unchanged.

The field data on which these mortality rates are based may not have been taken from years that represent long-term averages. Most of the years between 1980 and 1984 were years of poor reproductive success and high juvenile mortality (E. C. Meslow, personal communication). As with reproductive rates, predispersal and dispersal mortality rates of juveniles are highly variable among years, possibly because of an array of factors including the percent of unoccupied suitable habitat, weather, and availability of prey (Barrows, 1985).

Survivorship of subadults and adults is unknown. Barrowclough and Coats (1985) surmised that 0.85 was not an unreasonable estimate.

Table B-9

Spotted Owl Reproductive Rates

	Total No. Juveniles Observed\a	Total No. Pairs Observed	No. Juveniles per Pair\b	Reference
	8	21	0.38	Laymon and Barrett 1985
	38	96	0.40	Gutierrez and others 1985
	--- not given --		0.45	Barrows 1985
	80	119	0.67	Forsman and others 1984
	48	49	0.98	Meslow 1984 (1983 Annual Report)
	7	42	0.17	Meslow 1984
Total	181	327	0.55	

\a "No. juveniles" refers to juveniles of both sexes. Most juveniles were observed after their leaving the nest and probably before actually fledging, although most references were not specific on the precise dates of observations.
\b Includes pairs which had no young. Thus, the overall estimate of 0.55 juveniles of both sexes per pair is an average reproductive rate which accounts for those pairs that did not breed or did not produce young.

Young owls disperse from their natal roost area by September. They use a wider range of habitat structures than do adult owls (Gutierrez and others, 1985; Miller and Meslow, 1985). Dispersal distances of radio-harnessed juveniles have been reported from western Oregon (Forsman, 1980 - sample size = 4; Meslow, 1984 - sample size = 21) and northwestern California (Gutierrez and others, 1985 - sample size = 13). Combining the results of these studies, the maximum dispersal distance of juveniles, defined as the distance in a straight line from the natal area to the farthest radio point observed, averaged 27 miles (median = 23 mi, standard deviation = 15 mi, range 3 to 62 mi, sample size = 29 juveniles). The life table analysis is described more fully below.

Size of Home Ranges

The size of the home ranges of the northern spotted owl in Washington and Oregon have been estimated by radio telemetry studies (Table B-12). Home ranges of individual birds average 5526 acres, and composite home ranges of pairs average 7395 acres. There are ongoing studies (Brewer, 1985; H. Allen, pers. comm.) and these estimates will be revised.

For purposes of establishing and managing habitat areas on the National Forests, the amount of old-growth found within home ranges of owl pairs has been the key parameter. The amount of old-growth within the home range of pairs averages 2911 acres and ranges from 1008 to 5959 acres. Total home range of pairs averages 7395 acres and ranges from 3945 to 13,206 acres.

STATIC LIFE TABLE ANALYSIS

A life table is a statistical table showing rates of birth and survival by cohort or age class, and a static life table is such a summary based on only one period of time, usually the current conditions. In a static life table the population structure (the number of animals in each age class) takes on only one fixed set of values. The static life table is useful for: (1) calculating the rate of change of population size (called the population trend); (2) assessing the effects of different demographic parameters, such as birth and survival values, on population trends; and (3) comparing the demographic attributes and population trends of one species to similar, related species. Each of these uses are discussed below.

Calculating Spotted Owl Population Trends from Static Life Table Analysis

A static life table was calculated (Table B-13) based on the field-estimated demographic parameters reported above. Specifically, the parameters were a juvenile survival rate of 20 percent, an adult survival rate of 85 percent, a breeding rate of 0.55 young per pair per year, the third year of life as first year of reproduction, and a longevity of ten years. The breeding rate was based on both breeding and nonbreeding pairs. The current population trend was estimated from this life table by calculating the net reproductive rate (R_0). The net reproductive rate is

the number of female progeny birthed per adult female over her lifetime. When R_0 is less than 1, the population is declining; when = 1, remaining stable; and when is greater than 1, increasing. In this life table, R_0 is approximately equal to 0.24, suggesting a strongly declining population trend. Several discrepancies, however, were detected between the estimates of population trends from this estimate of R_0 as compared with evidence from other sources.

Table B-10

Pre-Dispersal Mortality Rates of Juvenile Spotted Owls

The following values, taken from the literature, describe numbers of juvenile spotted owls dying approximately between the dates of their leaving the nests to their dispersing from the natal roost area. This was during the second quarter of their life. The literature varied in the precision with which dates such observations were reported. There are no reported data on or estimates of mortality rates of spotted owl eggs, hatchlings, or nestlings.

Number Juveniles Observed	Number Juveniles Died	Percent Mortality	Year(s) Observed	Reference
29	10	35\a	1972	Forsman and others 1984
3	1	33	1975	Forsman and others 1984
1	1	100	1982	Laymon 1985
2	2	100	1983	Laymon 1985
60	27	45	1983, 1984, 1985	Meslow 1985 Annual Report
13	2	15	1983	Gutierrez and others 1985
8	6	75	1984	Laymon 1985
20	6	30	1984	Gutierrez 1985
136	55	40	Totals	

\a Forsman and others' (1984) observations during 1972 were made only up to August; excluding his observations, the weighted average juvenile mortality rate becomes 38 percent.

NOTE: Barrowclough and Coats (1985) estimated the second-quarter juvenile survivorship as 0.77 (thus, second-quarter juvenile mortality is 1 - 0.77 = 0.23, lower than this synthesis of data suggests [0.39]); however, they based their estimate only on data provided by Gutierrez and others (1985), and may also have erroneously transcribed numbers (namely, 10 of 13 juveniles survived; should have been 11 of 13 according to Gutierrez and others, 1985).

Table B-11

Dispersal Mortality Rates of Juvenile Spotted Owls

Area	Number of Juveniles	Fate[d]	Area	Number of Juveniles	Fate[d]
Klamath[a]	9	D	Roseburg &	8	D
	3	T	Medford[c]	1	T
	0	A	(1985 Data up	3	A
	1	S	to 20 April	0	S
			1986)		
			Total	33	D
Oregon Cascades[c]				7	T
	11+2[b]	D		7	A
	3	T		1	S
	2	A			
	0	S			
Coast Range[c]					
	3	D			
	0	T			
	2	A[e]			
	0	S			

[a]Gutierrez and others 1985
[b]Forsman and others 1984
[c]Miller and Meslow 1985 Annual Report (covers years 1983 and 1984 in Oregon Cascades and years 1982, 1983, and 1984 in the Coast Range)
[d]Fate: D = died during dispersal; T = transmitter failed during dispersal; A = alive at 12 months; S = settled after dispersal, transmitter failed.
[e]One juvenile alive after 12 months in the Coast Range subsequently died during the second year of life.

Dispersal mortality is estimated as:

$$\frac{D}{D + A + S} = \frac{33}{41} = 0.80 \text{ during dispersal}$$

Table B-12

Home Range Sizes and Old-Growth Areas Within Home Ranges of Individuals and Pairs of Northern Spotted Owls

All areas are expressed in acres.

Area	Individual Birds: Home Range	Individual Birds: Old-Growth Area\b	Pairs: Home Range	Pairs: Old-Growth Area
Washington and Oregon Only:				
Sample Size:	30	11\a	10	9
Minimum:	2273	836	3945	1008
Maximum:	15853	5523	13206	5959
Mean:	5526	2759	7395	2911
Standard deviation:	3141.6	1524.2	3334.4	1480.0
Coefficient of variation:	0.57	0.55	0.45	0.51
Standard error:	573.6	459.6	1054.4	493.3
Washington, Oregon, and California:				
Sample size:	38	19\a		
Minimum:	475	210		
Maximum:	15853	5523		
Mean:	4580	1802		
Standard deviation:	3350.9	1629.1		
Coefficient of variation:	0.73	0.90		
Standard error:	543.6	373.7		

\a None in Oregon.
\b Includes "mature" forest acres in California.

Sources:
Home Range Sizes:
Single birds: Washington (Brewer 1985, sample size = 16); Oregon (Forsman 1981, sample size = 6; Forsman et al. 1984, sample size = 8; California (Solis and Gutierrez 1982, sample size = 8).
Pairs: Washington (Brewer 1985, sample size = 4); Oregon (Forsman and Meslow 1985, sample size = 6); California (no data).
OLd-Growth Area:
Single birds: Washington (Brewer 1985, sample size = 11); Oregon (no data); California (Solis and Gutierrez 1982, sample size = 8).
Pairs: Washington (Brewer 1985, sample size = 3); Oregon (Forsman and Meslow 1985, sample size = 6); California (no data).

Table B-13

Female Spotted Owl Life Table

Based on 20 percent juvenile survival rate, 0.55 young/pair/year (0.275 female young) average reproductive rate, third year of life as first year of reproduction, and longevity of 10 years. See text for derivation of parameters. Calculations follow those shown in Caughley (1977).

x	m_x	q_x	p_x	d_x	l_x	$l_x m_x$	$x l_x m_x$
0	0	0.80	0.20	0.800	1.000	0	0
1	0	0.15	0.85	0.030	0.200	0	0
2	0.275	0.15	0.85	0.026	0.170	0.047	0.094
3	0.275	0.15	0.85	0.022	0.144	0.040	0.120
4	0.275	0.15	0.85	0.018	0.122	0.034	0.136
5	0.275	0.15	0.85	0.016	0.104	0.029	0.145
6	0.275	0.15	0.85	0.013	0.088	0.024	0.144
7	0.275	0.15	0.85	0.011	0.075	0.021	0.147
8	0.275	0.15	0.85	0.010	0.064	0.018	0.144
9	0.275	0.15	0.85	0.008	0.054	0.015	0.135
10	0.275	1.00	0	0.046	0.046	0.013	0.130
						0.239 = Net reproductive rate (R_0)	1.195

x = age class (e.g., $x = 0$ refers to the first year of life, between years 0 and 1)

m_x = birth rate, no. female progeny per female adult per year

q_x = mortality rate (e.g., 0.80 for $x = 0$ age class means that 80 percent of animals of age 0 die before reaching age 1)

p_x = survival rate (e.g., 0.20 for $x = 0$ age class means that 20 percent of animals of age 0 survive to age 1)

d_x = probability at birth of dying in each age interval x to $x+1$

l_x = probability at birth of surviving to age x

R_0 = net reproductive rate, number of female progeny birthed per adult female over her lifetime. When $R_0 < 1$, the population is declining; when = 1, remaining stable; and when > 1, increasing.

First, Forsman (personal communication) estimated that spotted owl populations have been declining in western Oregon on the order of 1.1 percent per year over the past decade. This rate of decline correlates with the rate of habitat loss. A similar rate of decline has been reported by Gordon Gould in California (personal communication). In contrast, the rate of decline suggested by the life table analysis (viz., $R_0 = 0.24$) was much more severe. A different life table (Leslie matrix model) analysis of the same field-estimated demographic data suggested the population would become extinct within 20 to 25 years. The Leslie matrix model was run to verify that the static life table calculations and the suggested population trends were accurately estimated from the field-estimated demographic data. Results of the static and the Leslie matrix life table analyses agreed closely.

Second, many suitable habitat areas have been found to be occupied. Results of National Forest surveys in Spotted Owl Management Areas (Tables B-14 and B-15) suggested that 68 percent of all surveyed sites are occupied by spotted owl breeding pairs that have been recently verified and that 70 percent of all surveyed and unsurveyed sites are occupied by at least one spotted owl. These figures seem to be inconsistent with a model that predicts imminent extinction.

There are at least two plausible explanations of the inconsistency between the life table prediction of imminent extinction, on the one hand, and recent population trends of a much lower rate of decline and the rather high observed percent occurrence of habitat areas, on the other hand. These explanations area: (1) both model and observations are correct and the populations are on the verge of a collapse; or (2) the demographic parameters in the life table are calculated incorrectly for estimating current population trends. Each of these explanations will be discussed in turn.

(1) Under the scenario of a population crash, and given an assumed ten-year life span of spotted owls, the current population is experiencing near-total reproductive failure and consists only of adults. The adults have a high fidelity to their sites and habitat areas will be occupied only as long as the current cohorts of adults survive. If populations are moribund, then extinction is a short-term and inevitable outcome under every habitat planning alternative, including the alternative that preserves all existing spotted owl habitat and provides for additional old-growth habitat over time. Additional analyses of genetic and environmental catastrophic effects on population viability are unnecessary.

How likely is it that spotted owl populations will indeed become extinct within 20 to 25 years, as suggested by the life tables? The scenario of a population crash can be neither totally verified nor discounted. Evidence that the scenario may be correct includes the observations that nearly all first-year spotted owls that have been followed with radio-telemetry equipment since 1982 have died during the first year or year and a half of life (Table B-11; E. C. Meslow, personal communication). The effect of radio harnesses, however, on survival of and foraging by first- and second-year spotted owls is unknown. Some inferential reasoning suggests

that the scenario of a population crash may not be the likely condition of the population. The reasoning is that many other species of raptors are known to have inconsistent rates of reproduction and survival over time.

One good breeding year may be followed by one or several poor years. An example is the tawny owl (Strix aluco) in Wytham Woods, England. The tawny owl population had steadily increased over the 13 years from 1947 to 1959, although there were two particularly poor reproductive years (1955 and 1958) during which reproductive success was virtually zero (Southern,1970). A long-lived species, such as the tawny or spotted owl, does not have to breed successfully every year in order to sustain or increase the size of the population. Rates of first-year survival of spotted owls were estimated from radio-tracked birds, although the radio-tracking studies were conducted over a relatively short length of time (1982 to 1985; Table B-10). One of those years saw relatively high breeding rates, although first-year survival has been consistently low.

Another piece of evidence against the scenario of a population crash is that data on the population structure of spotted owls in northwestern California suggest that approximately 24 percent of all owls are juveniles and 8 percent are second-year birds (calculated from data from A. Franklin, personal communication). The data are preliminary and the specific values will likely change. Nevertheless, that so many young owls are being discovered suggests that some successful reproduction and dispersal is occurring, at least in the northwestern California population. Whether the same population structure currently occurs in Oregon or Washington is unknown.

(2) The demographic parameters as estimated from the various field studies may be incorrectly calculated. This possibility was considered when the observations from the published literature and interim research reports that we used to estimate reproduction and survival rates were carefully examined. It became clear that some of the basic observations on reproductive rate, pre-fledging mortality, and dispersal mortality were not conducted or reported in a consistent manner.

For example, the information that was compiled from different studies on reproductive rates (Table B-9) was intended to represent the rate of production of juvenile owls when including both breeding and non-breeding adults. Including both breeding and non-breeding adults would take into account the proportion of the adult population that was not engaged in reproduction during any given year. It was important to include this in both the static and Leslie matrix life table analyses; otherwise, the structure of the life tables is such that all adults are assumed to be paired and breeding.

But the literature was often unclear as to precisely when, during the breeding sequence, observations of young were made (Figure B-2). A count of young owls at or near the nest site may have represented the number of owls leaving the nest, the number of owls just before fledging, the number of recently fledged young, or the number of fledged young ready to disperse. Reproduction rates (m_x) based on each of these estimates would directly affect what would be used to estimate first-year survivorship.

Table B-14

Spotted Owl Occupancy Classification

Following is the scheme used to classify results of surveys for spotted owls conducted in Spotted Owl Management Areas on National Forest land. This scale was used to estimate percent occupancy of habitat areas by spotted owl pairs.

Spotted Owl Occupancy Class	Description
[1]	Verified breeding pairs, surveys conducted since March 1982 (at least some direct evidence of breeding since March 1982).
[2]	Verified breeding pair, surveys conducted before March 1982 (evidence of breeding prior to March 1982, no evidence thereafter).
[3]	Verified presence of at least one owl, breeding status undetermined or no breeding known at any date.
[4]	Verified absence of any spotted owls; area adequately surveyed to detect owls if they were present.
[5]	Occurrence of owls unknown (area unsurveyed to date, no sightings within area, or surveys have revealed no owls but were inadequate to qualify for no. 4 above).

Table B-15

Estimation of Percent Occupancy of Spotted Owl Habitat Areas on National Forest Land in Washington and Oregon

See Table B-14 for descriptions of spotted owl occupancy classes.

Spotted Owl Occupancy Class	No. Spotted Owl Habitat Areas
[1]	144
[2]	110
[3]	370
[4]	20
[5]	249

Percent occupancy estimated as:

$$\frac{[1] + [2] + 1/2[3]}{[1]+[2]+[3]+[4]} = 0.68$$

The first year in the life table is defined as beginning when juvenile owls leave the nest. The first year could also be defined as beginning when juveniles fledge. The first year is not a fixed parameter as long as reproduction and survival estimates are calculated from the same life history sequence.

For example, if reproductive rate was based on the number of recently fledged owls, then first-year survival should be based on survival from the recently-fledged stage until the first year of life because the pre-fledging mortality rate would already be accounted for in the reproduction value. If the reproductive rate was based on the number of owls leaving the nest, then first-year survival should be based on the survival of young after leaving the nest. Such a calculation would include survival during the pre-fledging, fledging, and dispersal stages. The net result of imprecisely or inconsistently reported breeding and survival rates in the literature is an underestimate of survival or reproductive rates and an overestimate of the rate of population decline in the life table analyses. To help ascertain how definitions of survival and reproductive rates could influence the model outcomes, we also conducted life table sensitivity tests using demographic data of tawny owl populations; these tests are discussed below.

If the field-estimated values of reproduction and juvenile survival as presented above are assumed to not represent the true long-term averages, then the question arises as to what demographic values do represent average conditions. One approach to this question is to calibrate the life table model with values of demographic parameters that result in a population decline that more closely matches reported trends. The next section discusses calibration.

Assessing the Effects of Different Demographic Parameters

A series of sensitivity tests were run on the life table model using various values of demographic parameters (Table B-16). The sensitivity tests were run to determine which demographic parameters had the greatest influence on population trend, namely, on the net reproductive rate, R_0. Results suggested the following demographic parameters, listed in decreasing order of effect: first year survival (p_0), reproduction rate (m_x), first year of reproduction (whether ages two or three), and last year of reproduction (whether ages ten or fifteen).

Sensitivity tests were also run to determine which values of the two most influential demographic parameters - first year survival and reproduction rate - would cause a slightly declining population trend. The aim was to represent a population decline of about 1 percent per year, that is, the trend as approximated by Forsman and Gould and inferred from the percent of occupancy estimated from field surveys of habitat areas. The tests were run, assuming third year breeding as the first year of reproduction, a longevity of 10 years, and an adult annual survival of 0.85.

Results of the tests showed that a variety of values of first year survival (p_0) and reproductive rate (m_x) would provide for a slightly declining

```
TIME:

Mar - Apr        Apr - May         May - Jun                                                Sep                 Mar
 -1 mo.            0 mo.             1 mo.                                               3-4 mos.        10-11 mos.
   |----------------|-----------------|-------------------------------------------------------|------------------------------|

   |================|=================|=======================================================|==============================|
   ^                ^                 ^                                                       ^                              ^
   Eggs             Hatching          Young          ... Young fledge ...                     Disperse          Settle into
   laid                               leave nest                                                              new habitat
                                                                                                                     area

LIFE HISTORY STAGES:

   o----------------o-----------------o-------------------------------------------------------o------------------------------o
      Egg stage       Nestling stage      Parental            Fledgling stage                       Dispersal
                                         dependence,
                                         pre-flight

PERIODS OF MORTALITY ESTIMATES:

      CLUTCH SIZE      BROOD SIZE                                NO. FLEDGLINGS                  NO. JUV. DISPERSERS
   *----------------*-----------------*-------------------------------------------------------*------------------------------*
    Egg mortality      Nestling         Pre-fledging          Fledging mortality             Dispersal mortality
       period          mortality          mortality                 period
     (no data)          period
                       (no data)
```

Figure B-2. Life History Chronology of Spotted Owls, First Year of Life.

population. For example, the following combinations of values gave more or less equivalent results of population trends: $p_0 = 0.8$ and $m_x = 0.3$; $p_0 = 0.6$ and $m_x = 0.41$; and $p_0 = 0.4$ and $m_x = 0.55$. For purposes of running the life table assessments and in order for the analyses to be sensitive to variations in conditions of habitat, the values of $p_0 = 0.6$ and $m_x = 0.41$ were chosen. These fell in the central ranges of values.

Choosing the values of the first year survival and the reproduction rate to produce what was felt to be a reasonable resulting population trend does not imply that the specific values of $p_0 = 0.6$ and $m_x = 0.41$ are what have been or should be observed. If the scenario of a slight population decline is the correct one, then the values of these two parameters probably lie between these calibrated values and the lower, field-estimated values.

Comparing Demographic Attributes and Population Trends Among Owl Species: Comparison with Tawny Owl Population Data

To provide further insight into methods of defining the specific demographic parameters for the life table, a set of sensitivity analyses on tawny owl demographic data was run (Southern, 1970; Dempster, 1975). The objective of this exercise was to assess how well the net reproductive rate, as estimated from the life table analyses, matched known population trends and to determine which measures of reproduction and first-year survival rates would give reasonable estimates of the net reproductive rate. The estimates of demographic parameters of tawny owls was not used to estimate population trends of spotted owls.

Table B-16

Results of Sensitivity Tests on Spotted Owl Net Reproductive Rate from Varying Demographic Parameters

Tests are based on using static life table analysis (see Table B-13).

	Demographic Parameters Varied			Result
Test Number	Life Expectancy (yrs)[a]	Juvenile Survivorship (p_0)[b]	Reproductive Rate (m_x)[b]	Net Reproductive rate (R_0)[b]
1	10	0.07	0.275	0.08
2	10	0.20	0.275	0.24
3	10	0.44	0.275	0.53
4	10	0.07	0.375	0.11
5	15	0.07	0.275	0.09
6	10	0.44	0.375	0.72

[a] Age of last reproduction.
[b] See Table B-13 for description.

The tawny owl data set we used (Southern, 1970) included annual estimates of the total number of pairs, the number of breeding pairs, the mean clutch size, and the number of young fledged. These data were collected over a consecutive 13-year period, from 1947 to 1959, in Wytham Woods, England (Table B-17). Tawny owls are territorial the year around. Both breeding rate and territory size were observed to vary as a function of prey density, the prey being rodents. Tawny owl juveniles dispersing over a distance had lower survivorship than did juveniles dispersing more closely. Because of the high fidelity of pairs to a site and rapid replacement of adults, the number of adult territories in Wytham Woods remained more or less constant at about 30 pairs over a long period of time (1959-1974). The number of unpaired adults, however, fluctuated over time.

A high failure rate of eggs in the nest was observed. The causes of failure included desertion of the nest, predation, and the unexplained disappearance of eggs. In addition, the percent of a clutch hatching was observed to be inversely proportional to clutch size.

From Southern's (1970) information on demographic characteristics, the mean clutch size and mean fledging rate was estimated based on all breeding and nonbreeding pairs (Table B-17). This information was analogous to that calculated from the spotted owl data and was intended to include in the life table models the total size of the population and the trends based on all pairs. Because the life table approach assumes that all adults pair and breed each year, allowance for nonbreeding adults may be made by reducing the reproduction rate according to the average proportion of the adult population that does not breed. In the tawny owl population, on an annual average approximately 40 percent of the pairs do not breed (Table B-17).

The censuses conducted by Southern and others in Wytham Woods suggested that the total number of tawny owl pairs increased from 17 in 1947 to 32 in 1959, or an increase of 1.88 (88 percent) over the 13-year period. Average annual increase was 1.06 (6 percent per year). Therefore, the net reproductive rate should exceed 1, as the population is increasing.

Three tawny owl life tables were calculated based on different methods of estimating the age-specific reproductive rate (m_x). With each life table, the effect of varying the first year of reproduction (that is, age 2 or 3) on net reproductive rate was also explored. When m_x was represented by the mean fledging rate based on breeding and nonbreeding pairs (Table B-18), the net reproductive rate was calculated to be only 0.44 female progeny per adult female over her lifetime, assuming no second-year breeding, or 0.61, assuming second-year breeding. Again, the net reproductive rate should be 1.0 for a stable population and greater than 1.0 for an increasing population. The population survey data indicate an increasing population over the 13-year survey period. The conclusion is that representing m_x by a fledging rate calculated from breeding and nonbreeding pairs gives an estimate of a population trend that is too low.

When m_x was represented by the mean fledging rate based only on breeding pairs (Table B-19), net reproductive rate still fell under 1.0 both when assuming no second-year breeding and assuming second-year breeding.

Table B-17

Demographic Data on Tawny Owls in Wytham Woods, England, 1947-1959

Year	(a) No. Pairs	(b) Number Pairs Breeding	100(b)/(a) Percent Pairs Breeding	(c) Mean Clutch Size	(b)(c)/(a) Mean Clutch Size of All pairs	(d) Number Young Fledged	(d)/(a) No. Young Fledged Per pair[a]
1947	17	11	65	2.5	1.62	20	1.18
1948	20	13	65	2.0	1.30	20	1.00
1949	20	18	90	2.8	2.52	26	1.30
1950	20	17	85	2.6	2.21	25	1.25
1951	21	12	57	2.1	1.20	6	0.29
1952	24	17	71	2.5	1.77	21	0.88
1953	24	15	63	2.0	1.25	20	0.83
1954	26	18	69	2.5	1.73	17	0.65
1955	30	4	13	2.0	0.27	4	0.12
1956	32	21	66	2.2	1.44	24	0.75
1957	32	20	63	2.9	1.81	20	0.63
1958	31	0	0	0.0	0.00	0	0.00
1959	32	22	69	2.4	1.65	28	0.88
Means			60		1.42		0.75

Columns (a), (b), (c), and (d) are data from Southern (1970); the other columns are calculated from Southern's data.

[a]Number of young fledged per pair, accounting for all nonbreeding pairs (thus, derived from column (a) rather than from column (b)). Average number of young fledged per pair, accounting only for breeding pairs and weighted by the number of breeding pairs per year, is the average of (d)/(b) = 1.13.

Overall, the fledging rate gives too low an estimate of age-specific reproductive rate. Other possibilities would be to represent m_x by clutch size or brood size. No published information is available on tawny owl brood size.

When m_x was represented by the clutch size based on breeding and non-breeding pairs (Table B-20), the net reproductive rate exceeded 1.0 only when assuming second-year breeding. It is likely that at least some tawny owls breed in their second year of life. The value of the net reproductive rate was R_0 = 1.16 female progeny per adult female over her lifetime, which suggests that the population is increasing. This more or less matches the observed pattern of population size over time, although it may somewhat overestimate the rate of increase.

Table B-18

Female Tawny Owl Life Table Calculated from Data in Southern (1970)

Birth Rates (m_x) Represented by One-Half the Mean Fledging Rate and Based on Breeding and Non-Breeding Pairs.

x	m_x [a]	q_x	p_x	d_x	l_x	$l_x m_x$	$x l_x m_x$
ASSUMING NO SECOND-YEAR BREEDING:							
0	0	0.53	0.47	0.530	1.000	0	0
1	0	0.21	0.79	0.099	0.470	0	0
2	0.375	0.14	0.86	0.052	0.371	0.139	0.278
3	0.375	0.17	0.83	0.054	0.319	0.120	0.360
4	0.375	0.20	0.80	0.053	0.265	0.099	0.396
5+	0.375	1.00	0	0.212	0.212	0.080	0.400
					R_0 =	0.438	
ASSUMING SECOND-YEAR BREEDING:							
0	0	------- same as above -------				0	0
1	0.375					0.176	0.176
2	0.375					0.139	0.278
3	0.375					0.120	0.360
4	0.375					0.099	0.396
5+	0.375					0.080	0.400
					R_0 =	0.614	

Calculations follow Caughley (1977). See Table B-13 for descriptions of parameters.

[a]Reproductive rate m_x = 1/2 (mean fledging rate for breeding plus nonbreeding pairs) = 1/2 (0.75 juvenile tawny owls of both sexes fledged per pair per year) = 0.375 juvenile females fledged per pair per year.

The lesson to be learned from this exercise with the tawny owl data is that, other parameters held constant, estimated population trend is rather sensitive to the way that the age-specific reproductive rate is defined and denoted in the life table model. Considering the information from both the tawny owl and spotted owl, if the first-year survival is estimated from data on mortality of the owlets after they have just left the nest, the age-specific reproductive rate is best estimated by approximating a value in between the clutch-size and the fledging rate. This reproductive rate would be based on breeding and non-breeding pairs.

The implication is that population trends as predicted through the spotted owl life tables presented above may be pessimistic and that life tables cannot be expected to completely and accurately represent expected

population trends. Life table models assume that all adults pair and breed and that breeding is done on a regular basis (i.e., every year). Life tables do not explicitly represent the annual variations in reproductive rate and population size for species whose characteristics may vary from those assumed by the model. For instance, life tables represent poorly species that may breed irregularly or species that have a variable and significant proportion of adults that do not breed. Spotted owls seem to have both of these characteristics. Still, the life table approach is an appropriate tool for assessing the effects of population structure and average demographic characteristics on population trends, given the assumptions inherent in the model.

Table B-19

Female Tawny Owl Life Table Calculated from Data in Southern (1970) Birth Rates (m_x) Represented by Using a Weighted Mean Fledging Rate Based Only on Breeding Pairs.

x	m_x[a]	q_x	p_x	d_x	l_x	$l_x m_x$	$x l_x m_x$
ASSUMING NO SECOND-YEAR BREEDING:							
0	0	0.53			1.000	0	0
1	0	0.21	Same as		0.470	0	0
2	0.565	0.14	in Table		0.371	0.210	0.420
3	0.565	0.17	B-18		0.319	0.180	0.540
4	0.565	0.20			0.265	0.150	0.600
5+	0.565	1.00			0.212	0.120	0.600

					R_0 =	0.660	
ASSUMING SECOND-YEAR BREEDING:							
0	0	------- same as	above -------			0	0
1	0.565					0.266	0.266
2	0.565					0.210	0.420
3	0.565					0.180	0.540
4	0.565					0.150	0.600
5+	0.565					0.120	0.600

					R_0 =	0.926	

Calculations follow Caughley (1977). See Table B-13 for descriptions of parameters.

[a]Reproductive rate m_x = 1/2(mean fledging rate for breeding pairs only) = 1/2 (1.13 juvenile tawny owls of both sexes fledged per breeding pair per year) = 0.565 juvenile females fledged per breeding pair per year.

Table B-20

Female Tawny Owl Life Table Calculated from Data in Southern (1970) Birth Rates (m_x) Represented by Using Mean Clutch Rate Based on Breeding and Non-Breeding Pairs.

x	m_x [a]	q_x	p_x	d_x	l_x	$l_x m_x$	$x l_x m_x$
ASSUMING NO SECOND-YEAR BREEDING:							
0	0	0.53			1.000	0	0
1	0	0.21	Same as in		0.470	0	0
2	0.71	0.14	Table B-18		0.371	0.263	0.526
3	0.71	0.17			0.319	0.226	0.679
4	0.71	0.20			0.265	0.188	0.753
5+	0.71	1.00			0.212	0.151	0.753
					R_0 =	0.828	
ASSUMING SECOND-YEAR BREEDING:							
0	0	------- same as above -------				0	0
1	0.71					0.334	0.334
2	0.71					0.263	0.526
3	0.71					0.226	0.679
4	0.71					0.188	0.753
5+	0.71					0.151	0.753
					R_0 =	1.162	

Calculations follow Caughley (1977). See Table B-13 for descriptions of parameters.

[a] Reproductive rate m_x = 1/2(clutch size averaged over breeding and non-breeding pairs) = 1/2 (1.42 eggs of both sexes laid per breeding pair per year [see Table B-17]) = 0.71 eggs of females laid per breeding pair per year.

EFFECTS OF VARIABLE BIRTH AND DEATH RATES ON PERSISTENCE OF POPULATIONS

Variation in birth and survivorship rates is one factor that may cause populations to become extinct, at least locally (Shaffer, 1985). The probability of extinction from this factor is a function of the average rates birth and death, the variation of rates of birth and death, the absolute size of the population, and the relative impacts from other causes of extinction. Considering the last of these, a population may suffer extinction because of factors such as environmental catastrophes before it dies off from random low birth rates and high death rates.

Means and standard deviations of birth and survivorship rates were used in a Leslie matrix life table that projects population size, by year, to year 100. The outcome of using field-derived estimates of the average birth and survivorship rates were first tested. The field-derived average reproduction rate of 0.55 juveniles of both sexes per pair per year (Table B-9) and a juvenile survivorship of 0.20 (discussed above) were used. Results of this test were that the population numbers predicted by using the average values obtained from the field data were not the same as those observed. Rather, the predicted population crashed under all habitat conditions examined. The field values may likely have been biased toward being low because of the series of years during which the studies were conducted were by chance were ones in which there were poor reproductive success and high juvenile mortality. Consultation with the spotted owl researchers confirmed the suspicions that the populations projected by the model when using the field values may be unrealistically pessimistic. Thus, we chose to calibrate the Leslie life table model with those average values for the reproductive rate (0.80 juveniles of both sexes per pair per year) and juvenile survivorship (0.60) that gave more reasonable population dynamics. This was done in order to better interpret the effects of different initial habitat conditions.

The variability of birth rate was estimated by dividing the mean rate of the observed reproduction of females by 3. The value 3 was used to avoid generating negative birth rates in the model. The number of females born was assumed to be one-half the number of all juveniles born (0.55 juveniles per pair per year). This gave an estimated standard deviation of 0.09 females per pair per year (0.09 = (0.28 mean birth rate) / 3). This was used in the Leslie matrix model as a randomly selected upper limit to add to or subtract from the mean (0.28) in order to account for much of the variability of birth rates.

Variability of the survivorship rate was also estimated by dividing the juvenile mortality rate by 3, as used in the Leslie matrix model. This was estimated to be (1 - 0.60)/3 = 0.13. The value 3 was used to avoid generating negative values of survival rates in the model.

Another factor used in the Leslie matrix model was the total, or initial, population size, that is, the total numbers of breeding pairs. This was estimated from the habitat capability of each population isolate for each planning alternative and each time horizon. The total population size was derived by taking the capability for breeding pairs and adding to it numbers of subadults and juveniles in order to match the observed population structure as to the relative numbers of adults, subadults, and juveniles. The population structure was taken from a study of spotted owls in progress in northwestern California (A. Franklin, personal communication).

Each planning alternative was analyzed according to each population isolate within the different physiographic provinces or groups of provinces. The Leslie matrix model was run 20 times for each of the initial population sizes of the various alternatives. Populations were defined as falling below recoverable levels of distribution when numbers of spotted owl pairs were predicted to be fewer than that at an effective extinction level in each population isolate.

PROBABILITY OF PERSISTENCE

OLYMPIC PENINSULA

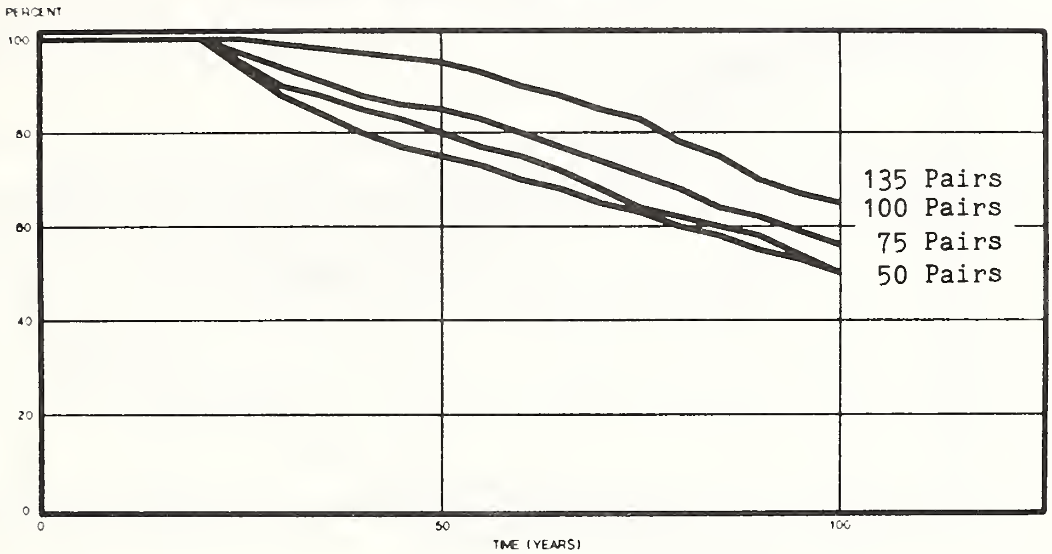

Figure B-3. Percent Probability of Avoiding Extinction from Demographic Variation up to Specified Points in Time. Results are Shown for Various Starting Population Sizes.

PROBABILITY OF PERSISTENCE

WASHINGTON CASCADES

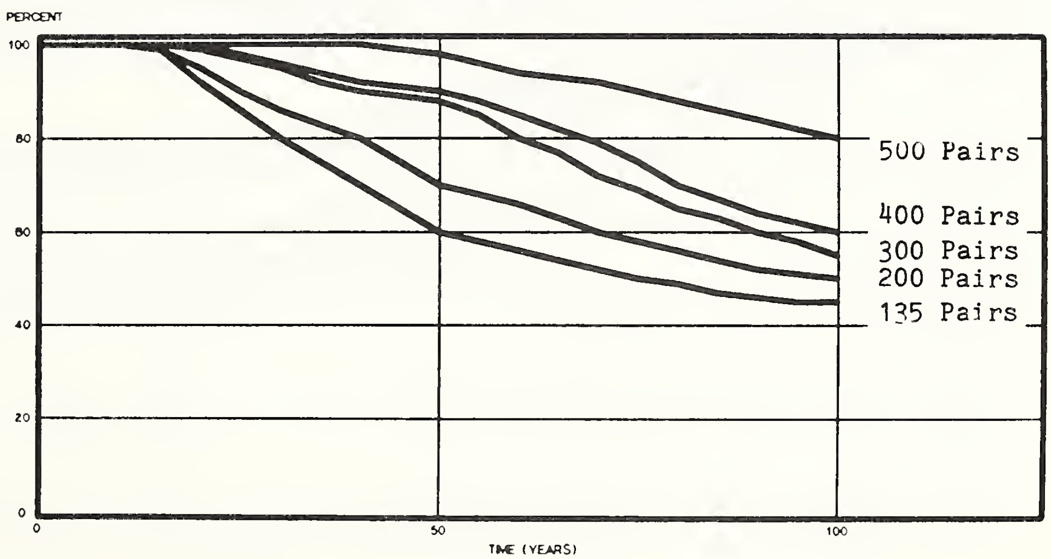

Figure B-4. Percent Probability of Avoiding Extinction from Demographic Variation up to Specified Points in Time. Results are Shown for Various Starting Population Sizes.

PROBABILITY OF PERSISTENCE

OREGON CASCADES, KLAMATH AND OREGON COAST RANGE

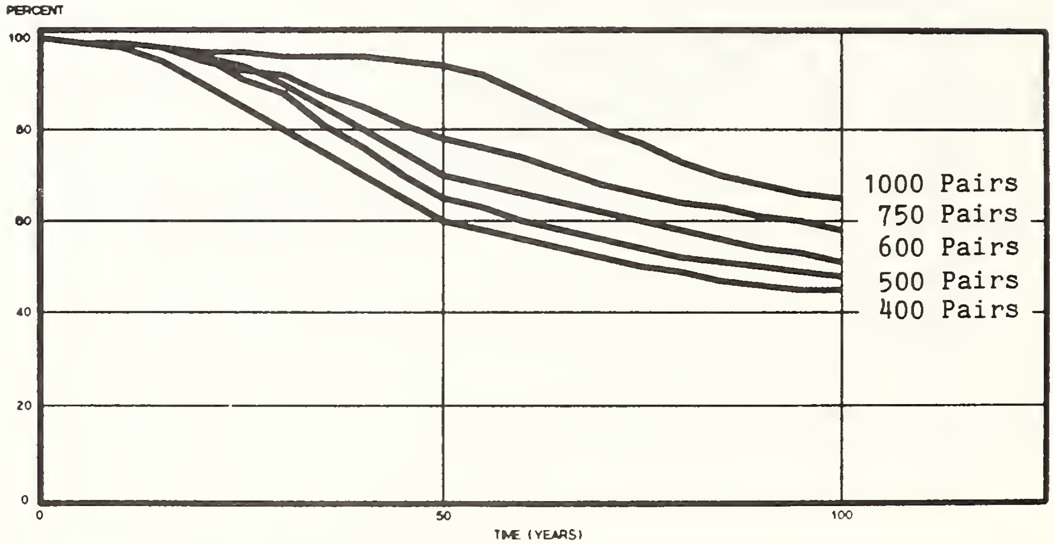

Figure B-5. Percent Probability of Avoiding Extinction from Demographic Variation up to Specified Points in Time. Results are Shown for Various Starting Population Sizes.

PROBABILITY OF PERSISTENCE

WASHINGTON & OREGON CASCADES, KLAMATH, AND OREGON COAST RANGE

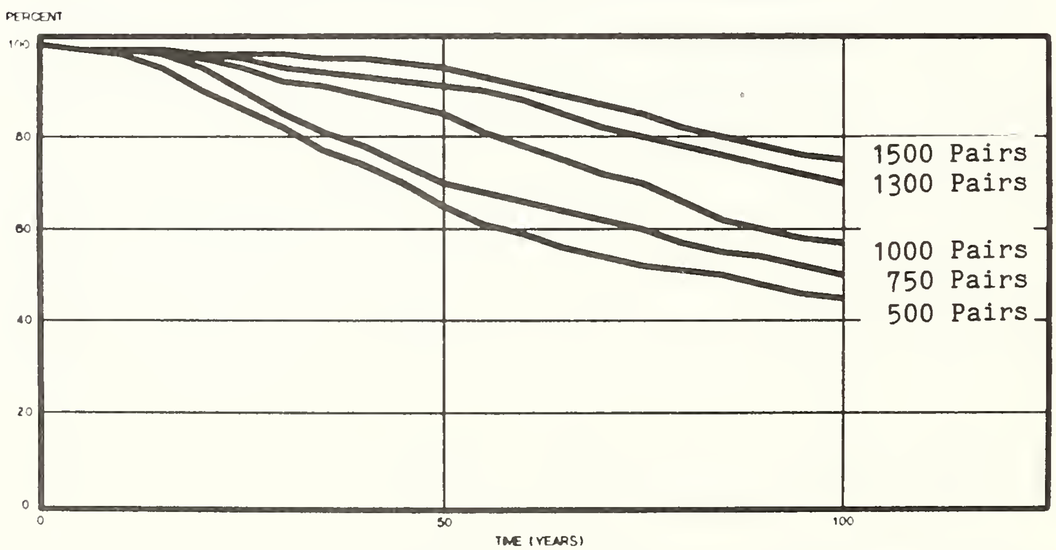

Figure B-6. Percent Probability of Avoiding Extinction from Demographic Variation up to Specified Points in Time. Results are Shown for Various Starting Population Sizes.

PROBABILITY OF PERSISTENCE

OREGON COAST RANGE

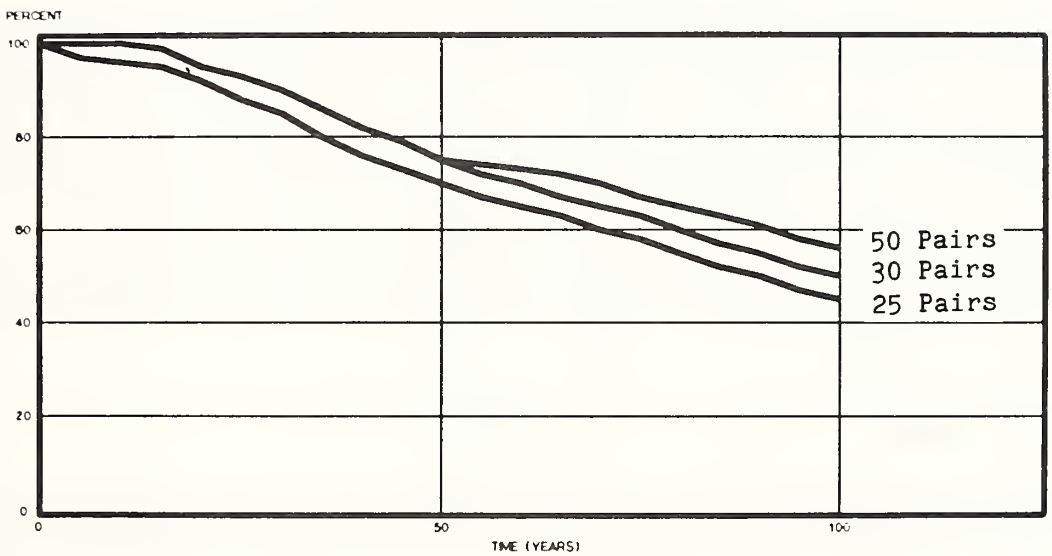

Figure B-7. Percent Probability of Avoiding Extinction from Demographic Variation up to Specified Points in Time. Results are Shown for Various Starting Population Sizes.

The effective extinction level of each population isolate was defined as the total number of owl pairs that would occur in each physiographic provinces or combination if they were distributed such that the distance between the nearest neighboring pairs of owls was the median juvenile dispersal distance of 23 miles. The effective extinction levels were calculated by dividing the total area of each physiographic province by the density of pairs spaced at intervals of 23 miles. Effective extinction levels were calculated to be 4 pairs on the Olympic Penninsula, 16 in the Washington Cascades, 19 in the Oregon Cascades, 16 in the Klamath Mountains, and 3 in the Oregon Coast Range. The frequency of runs in which the population was projected to fall to or below the effective extinction levels gave the probability of extinction for the initial population size.

Results of running the Leslie matrix model were summarized in tables showing the proportions of runs in which the total numbers of pairs fell below the effective extinction levels in each population isolate. The results were used to determine the probabilities of populations with a given numbers of pairs falling below effective extinction levels based on chance variations in birth and death rates. Results are presented in Figures B-3 to B-7 that illustrate probabilities of persistence for each physiographic province and for various population sizes. These probabilities were combined with the estimated effects of inbreeding, size of habitat, and distribution for each population isolate during each time period (Table B-23).

GENETICS MODELS

Populations may become locally extinct because of loss of genetic heterogeneity through inbreeding. The probability of populations incurring excessive loss of genetic heterogeneity was estimated by using the formula of Hartl's (1980), as presented in Salwasser and others (1984). The inbreeding coefficient was thus derived (Table B-21). The calculation accounted for the effective population size (number of interbreeding animals) and the number of generations over which inbreeding would occur, and was applied to each population isolate.

Specifically, inbreeding rates were calculated as follows:

1. Determine the size of a population that would be panmictic. Three steps are required:

    a. Determine which populations are isolated or assumed to be isolated by barriers. Specifically, the Olympic Peninsula and Coast Range populations were determined to be isolates by means of analyzing the distances between neighboring habitat areas (described previously) and by simulations of dispersal of owls. The Columbia River Gorge was treated both as a barrier to dispersal and as a corridor allowing dispersal.

    b. For each resulting isolate, determine the density of breeding adults. Use this density to calculate the quantity (rho)(sigma^2), where rho is density (number of breeding

adults per square mile) and sigma is the root mean square dispersal distance of juveniles. The current value of sigma is 14.9 miles.

Table B-21

Values of the Inbreeding Coefficient (F_t) as a Function of Population Size and Time

Effective population size (N_e)[a]	(3)	Time in years (no. generations in parentheses)[b] 15 (10)	50 (20)	100 (30)	150 (100)	500
25		0.06	0.18	0.33	0.45	0.86
50		0.03	0.10	0.18	0.26	0.63
75		0.02	0.06	0.12	0.18	0.49
100		0.02	0.05	0.10	0.14	0.39
150		0.01	0.03	0.06	0.10	0.28
200		0.01	0.02	0.05	0.07	0.22
250		0.01	0.02	0.04	0.06	0.18
300		0.005	0.02	0.03	0.05	0.15
350		0.004	0.01	0.03	0.04	0.13
400		<0.004	0.01	0.02	0.04	0.12
450		¦	0.01	0.02	0.03	0.10
500		¦	0.01	0.02	0.03	0.10
600		¦	0.008	0.02	0.02	0.08
700		¦	<0.008	0.01	0.02	0.07
800		¦	¦	0.01	0.02	0.06
900		¦	¦	0.01	0.02	0.05
1000		¦	¦	0.01	0.01	0.05
1100		¦	¦	0.009	0.01	0.04
1200		¦	¦	<0.009	0.01	0.04
1300		¦	¦	¦	0.01	0.04
1400		¦	¦	¦	0.01	0.04
1500		¦	¦	¦	0.01	0.03

[a] Adjusted number of breeding adults. See text for calculations of N_e.
[b] Generation time of spotted owls estimated as 5 years.

c. If (rho)(sigma^2) is greater than 1.0, then the isolate is considered panmictic and N simply equals the total number of breeding adults. If (rho)(sigma^2) is less than or equal to 1.0, then the isolate is not considered panmictic and N should be estimated from the isolation-by-distance formula N = 4(pi)(rho)(sigma^2).

2. Effective population size, N_e, is now determined from the total number of breeding adults, N, by using the following formula:

$$N_e = N \times F_{SR} \times F_K \times F_{RS} \times F_{GT} \times F_{FP}$$

where

F_{SR} = correction factor for unequal adult sex ratio

F_K = correction factor for nonnormality of dispersal distribution

F_{RS} = correction factor for variation in reproductive success

F_{GT} = correction factor for overlapping generations

F_{FP} = correction factor for fluctuating population size

Estimated values of these factors are:

$F_{SR} = 1$

$F_K = 0.93$, based on interpolation from Barrowclough and Coats (1985)

$F_{RS} = 0.64$, based on observed variation in reproduction and formula from Barrowclough and Coats (1985)

$F_{GT} = 1$; according to Barrowclough and Coats (1985), this factor is 1 if only breeding adults are included in N

$F_{FP} = 0.8$ (derivation shown below)

and the solution for effective population size becomes:

$$N_e = N \times 1 \times 0.93 \times 0.64 \times 1 \times 0.8 = 0.48 N.$$

3. Calculate inbreeding coefficient according to:

$$F_t = 1 - \left(1 - \frac{1}{2N_e + 0.5}\right)^t$$

where t is the number of generations over which inbreeding is to be calculated. Generation time was determined to be 5 years based on the basic life table approach (e.g., Krebs, 1978; Caughley, 1977).

We determined when inbreeding had caused excessive loss of genetic heterogeneity when F_t was equal to or greater than 0.5 (Frankel and Soule, 1981). At this rate of inbreeding, natural selection is unable to offset the fixation of deleterious recessive alleles in the population. The result is that the population suffers depressed reproductive success and may not be able to sustain even short-term preservation of fitness.

Considering the sizes of the populations resulting from the habitat capability provided by the various alternatives and the assumptions made

about the isolation of populations, the results of the calculations suggested that genetic factors had less influence on probabilities of continued existence than did demographic factors. Variations in birth and survivorship rates influenced the probability of continued existence more than did rates of inbreeding and loss of genetic heterogeneity. Thus, we focused on demographic factors as potential causes of extinction. Our conclusion in this regard was supported in theory by Shaffer (1985).

ENVIRONMENTAL CATASTROPHE MODELS AND SPECIES INTERACTIONS

Environmental Catastrophes

Another factor that may influence continued existence of a population is the occurrence of environmental catastrophes. The ideal method for assessing the probability of loss of habitat and extinction of populations resulting from catastrophes is to apply field data on the location, frequency, and area affected by windstorms, fire, insects, and volcanoes. Unfortunately, such data were unavailable or nonexistent. Thus, the effects of catastrophes were treated in an ad hoc fashion.

The planning alternatives called for preserving or developing spotted owl habitat areas, each providing a different configuration and size. Generally, the smaller and more isolated the habitat areas are, the more susceptible they are to devastation by catastrophic events. Damage from windstorms becomes a greater risk when suitable spotted owl habitat areas are adjacent to young-growth forest stages, especially recently harvested stands (Ruediger, 1985), than if the stand was buffered by older (and taller forest stands. Risk of habitat loss from windstorms is also higher when the habitat area is small, although specific topographic and geographic location strongly dictates the degree of risk. The Christmas Day windstorm in 1983 caused 215 acres of habitat loss in six spotted owl management areas in the southern Washington Cascades (Ruediger, 1985).

Risks from fire are similar to risks from windstorms in that the more isolated and smaller a habitat area is, the greater is the risk that most or all of the habitat area would be lost.

In the range of the northern spotted owl, loss of suitable spotted owl habitat from insects and disease is often an aftermath of fire and windstorms. Insects and disease are seldom a primary factor in the loss of habitat in western Washington and Oregon.

Over the long run, the eruption of volcanoes is an authentic threat to habitat over the long run. The eruption of Mt. St. Helens in 1980 eliminated about 25,000 acres of mature and old-growth forest on National Forest land known to contain a high density of spotted owls (Ruediger, 1985; Garcia, 1979). The dormant volcanoes in the Cascade Range, as well as Mt. St. Helens, may pose similar threats to habitat within the next few centuries. No estimates of frequency, duration, intensity, and effects of volcanic activities on forest habitat are available.

Species Interactions: Habitat Competition with Barred Owls

Barred owls (*Strix varia*) have been expanding their range into the Pacific Northwest over the past 20 years. There have recently been regular reports of barred owls in the British Columbia mainland, Vancouver Island, the Olympic Peninsula, Washington Cascades, and Oregon Cascades (Taylor and Forsman, 1976; Allen and others, 1985; Hamer and Allen, 1985). They also have been sighted several times in northwestern California. Allen and others (1985) reported that there are, in Washington, instances of barred owls occupying territories that had previously been occupied by spotted owls.

Allen and others (1985) surmised that at least some pairs of spotted owls may be in peril from being out-competed for habitat use by barred owls. The rate of dislocation can be only crudely estimated at the current time, however, and the future effect of the competitive owl interactions on the population viability of spotted owls cannot be predicted. Allen and others recommended that, at least in northwestern Washington, spotted owl habitats be established as large, contiguous blocks of forest in mid- to upper-slope topographic areas. This would reduce suitability of habitats for barred owls.

Species Interactions: Predation by Great Horned Owls

A second species that may be causing a decrease in the distribution or abundance of spotted owls is the great horned owl (*Bubo virginianus*). Great horned owls typically inhabit mixed woodlands and are known to prey on young spotted owls (Forsman, 1980). Great horned owls may increase in numbers locally as mature or old-growth forest is harvested and young-growth forest and forest edges increase in acreage and extent across the managed forest landscape. Despite this supposition, the relationship between the abundance of great horned owls and forest fragmentation and the influence that the great horned owls' predation has on the population trends of the spotted owl are essentially unknown. At this time no quantitative relationships can be conjectured or guidelines established for considering the effect of predation pressure when assessing the viability of spotted owl populations.

ACCOUNTING FOR CATASTROPHES AND SPECIES INTERACTIONS IN PROBABILITIES OF PERSISTENCE

The occurrence of environmental catastrophes and species interactions and their influence on population viability of spotted owls could not be quantified and included in the calculations of habitat capability and the likely distribution and abundance of spotted owls. It is recognized that those planning alternatives that result in fragmentation and isolation of suitable habitat may have as an effect a greater risk of catastrophic loss of habitat areas, as well as invasion by barred owls into individual sites. Those alternatives that retain suitable habitat in larger, more contiguous arrangements may have as an effect lower risks. Larger, more contiguous stands may also be less susceptible to changes in vegetation

structure and microclimate conditions within the stand. The risk of habitat loss from volcanic activity may be independent of habitat distribution. All the risk factors were considered qualitatively when estimating the probabilities of persistence of spotted owl populations as the potential effects of habitat size were assessed.

OVERALL PROBABILITIES OF PERSISTENCE

The purpose of this step was to summarize the above analyses in a rank order scale showing probabilities of persistence to specified time periods under each planning alternative. The probability of persistence may be thought of as the probability of avoiding the various causes of extinction to a specific time period. In concept, a population would have to avoid extinction from demographic, genetic, and environmental factors. How these various factors interplay is poorly understood for wild populations. For example, a period of poor reproduction and high juvenile mortality, such as may be caused by bad weather or low numbers of prey may set the stage for increased genetic risk or isolation of subpopulations caused by catastrophic changes to portions of the habitat. For the purposes of analysis, it was not possible to consider the variations of how these factors interact with each other. At the current level of understanding, the effects of the factors are best combined to represent a general probability of persistence.

The specific factors considered in the analysis (Table B-22) include estimating: (1) the potential effects of variable rates of birth and death; (2) effects of inbreeding depression and genetic drift; (3) effects of habitat size and quality on the probability of use and distribution of breeding individuals; and (4) the effect of habitat distribution on colonization and occupancy by breeding individuals. Additional factors, such as frequency of occurrence of competitors, predators, and disease were considered in the assessment.

Viability was defined as the likelihood that a well-distributed population would persist through a specified duration of time. The "specified duration of time" was a spectrum of time periods at years 0 (that is, current condition), 15, 50, 100, 150, and 500. Results of the viability assessments were therefore phrased in terms of the probability that a well-distributed population was likely to persist up to a particular year. Then, it became the role of the decision-maker to select a desirable probability and duration of time by weighing the various biological, social, and economic factors, as well as resource trade-offs and implications of scientific uncertainty under each of the habitat management alternatives.

The following rank order scale representing probabilities of persistence was devised:

VERY HIGH (VH): Continued existence of a well-distributed population on the planning area at the future date is virtually assured. There is latitude for catastrophic events affecting the population or for findings

that the species is less flexible in its habitat requirements or that demographic or genetic factors are more significant than were assumed in the analysis.

HIGH (H): There is a high likelihood of continued existence of a well-distributed population on the planning area at the future date. There is limited latitude for catastrophic events affecting the population or for biological findings that the population is more susceptible to demographic or genetic factors than was assumed in the analysis.

MODERATE (M): There is a moderate likelihood of continued existence of a well-distributed population on the planning area at the future date. There is no latitude for catastrophic events affecting the population or for biological findings that the population is more susceptible to demographic or genetic factors than was assumed in the analysis.

LOW (L): There is a low likelihood of continued existence of a well-distributed population on the planning area at the future date. Catastrophic, demographic, or genetic factors are likely to cause extirpation of the species from parts or all of its geographic range.

VERY LOW (VL): There is a very low likelihood of continued existence of a well-distributed population on the planning area at the future date. Catastrophic, demographic, or genetic factors are highly likely to cause extirpation of the species from parts of or all of its geographic range.

The probability of persistence of each population isolate was estimated for each combination of planning alternative and time period. Note that although each extinction factor is assessed on a quantitative scale, the final combination of all factors returns to the 5-class rank order scale shown above.

A set of rules was established to summarize the results of the analyses (Table B-23) into the probability of persistence scale. In this fashion, the results of the viability assessments approximate a risk analysis. No particular population size became the "minimum viable" level; viability was expressed as a graded series of probabilities of continued existence.

The criteria used to assign probabilities of persistence (Table B-23) focused on three main factors: population dynamics (that is, the demographic and genetic responses), habitat size, and habitat distribution. The specific ranges of values were developed that suggest the various probabilities of persistence levels. As an example of how Table B-23 was used, a population would rate at the "very high" end of the scale - that is, to ensure that a population of spotted owls is well distributed at a particular time period with a cushion for unexpected events or findings - when the following criteria were met: (1) population size must exceed effective extinction levels with a greater than 95 percent likelihood in spite of variable birth and death rates; (2) populations must incur no greater than a 0.05 inbreeding rate; (3) habitat acres for each pair must be available to provide over a 95 percent assurance of occupancy by a breeding pair; (4) habitat areas must be occupied at a rate greater than 95 percent of the initial occupancy rate; and (5) distances between the next nearest habitats must average less than 4 miles.

Estimates of habitat capability and the likely population sizes and degrees of isolation were generated for each management alternative and time horizon. The rule set for probabilities of persistence (Table B-23) was then used along with information on habitat capability, size, and distribution. The results were estimates of probabilities of persistence for each combination of planning alternative, population isolate, and time.

Table B-22

Sample Worksheet for Recording Probabilities of Persistence of Spotted Owl Populations by Alternative Management Strategy, Population, Time Period, and Factors Potentially Causing Extinction

Probability of Persistence of a Well-Distributed Population by Alternative, Population Isolate, and Year

Management Alternative _____   Population Isolate ___________________________________

	Demographic and Genetic Stability		Habitat Size[a]	Habitat Distribution		OVERALL PROBAB LEVEL
Year (Capability Expressed as Number Pairs)	Demo-graphic Effect (Prob. of N > min)	Genetic Effect (Inbreed. coeffic.)	HSI Value	Percent Occupancy (Simula-tion)	Nearest-Neighbor Dist. (mi)	
0						
15						
50						
100						
150						
500						

[a] Refers to Forest Service non-reserved spotted owl management areas only.

Table B-23

Rule Set for Estimating Probability of Persistence of a Population, as Used With Northern Spotted Owls in Oregon and Washington

	Demographic and Genetic Stability		Habitat Size	Habitat Distribution	
Probab. Level[a]	Demographic Effect (Prob. of N > min)[b]	Genetic Effect (Inbreed. coeffic.)	HSI Value[c]	% of Starting Occupancy Rate (From Simulation Model)	Nearest Neighbor Distance (mi)
VERY HIGH	>0.95	≤0.05	>0.95	>95	<4
HIGH	0.80-0.95	0.06-0.20	0.80-0.95	80-95	4-6
MODERATE	0.60-0.79	0.21-0.35	0.60-0.79	60-79	7-12
LOW	0.40-0.59	0.36-0.50	0.40-0.59	40-59	13-27
VERY LOW	<0.40	>0.50	<0.40	<40	>27

[a] See previous discussion for definition of probabilities of persistence classes.

[b] Probability that a population, with stochastic birth and death rates, will exceed effective extinction levels within a specified period of time. Effective extinction levels may be defined as the lowest population density to meet distribution criteria.

[c] Habitat Suitability Index values that relate total area of suitable habitat to probability of occupancy by a breeding pair.

Appendix C

THE SPOTTED OWL: A LITERATURE REVIEW

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Please Note: Much of the material cited in this review is unpublished. In many of the unpublished reports that were reviewed, data was not fully presented or analyzed, either because the studies were not complete or because the authors did not choose to release the information until they had time to do a more complete analysis and to subject their results to peer review. It is entirely possible that conclusions and interpretations in some of the unpublished reports will change considerably after the authors have had time to fully collect and analyze their data and to seek peer review.

SPECIES DESCRIPTION AND DISTRIBUTION

Physical Characteristics

The spotted owl is a medium-sized owl with a round head, dark-brown plumage, and dark eyes. It has white spots on the head and nape, and white mottling on the breast and abdomen; thus the name, spotted owl. The sexes are alike except that females average slightly larger and have higher pitched calls than males. Aside from its appearance, the most distinctive feature of the spotted owl is its extremely unwary behavior around humans. Spotted owls are so tame in fact, that they will usually let human observers approach within a few feet before flying away (Bent 1938; Forsman, 1983).

The only species with which the spotted owl might be confused is the closely-related barred owl (Strix varia). Barred owls average slightly larger in size than spotted owls and have a distinct pattern of horizontal bars on the breast and vertical streaks on the abdomen. Unlike spotted owls, barred owls are wary and usually fly away when approached. The barred owl has invaded the Pacific Northwest and northern California in recent years and appears to be displacing the spotted owl in some areas (Taylor and Forsman, 1976; Grant, 1966).[1/]

Taxonomy and Distribution

Three subspecies of the spotted owl are currently recognized by the American Ornithologists' Union (1957): the northern spotted owl (Strix occidentalis caurina), the California spotted owl (S. o. occidentalis), and the Mexican spotted owl (S. o. lucida). These subdivisions are based primarily on slight differences in color of plumage (Merriam, 1898; Nelson, 1903). Genetic variation among or within subspecies has not been studied.

Oberholser (1915) reported that there was considerable overlap in color of plumage between the northern and California subspecies. He recommended that the two subspecies be combined. This recommendation has never been adopted by the American Ornithologists' Union, presumably because morphological characteristics are no longer considered a conclusive indicator of subspecific differences. In summary, the subspecific taxonomy of the spotted owl needs further study. Specifically, modern techniques of starch-gel electrophoresis need to be used to determine the amount of genetic variation among and within regional populations of the spotted owl, throughout the range of the species.

The northern spotted owl is confined to southwestern British Columbia, the coastal mountains and Cascade Range of Oregon and Washington, and the Klamath Mountain's Province which includes Southwestern Oregon and the coastal mountains of northwestern California north of San Francisco. In Oregon and Washington, the species is found on both the west and east

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1/ Personal communication, H. Allen, Washington Department of Game, Olympia, Washington.

slopes of the Cascade Range, but is rarely found in the mountains east of the Cascades. There is some concern in Washington State that spotted owls on the Olympic Peninsula now may be geographically isolated from the rest of the population (Juelson, 1985). Whether the extent of isolation is sufficient to restrain gene flow between the peninsula and inland areas is not known.

The California spotted owl is confined to the Sierra Nevada Mountains and the coastal mountains of California south of San Francisco (Dawson, 1923; American Ornithologists' Union, 1957; Bent, 1938). It may range south into northern Baja California, but this has not been verified.[2/]

The Mexican spotted owl occurs from southern Colorado and central Utah, south in the higher mountains through Arizona, New Mexico and extreme western Texas (the Guadalupe Mountains) into Mexico. In Mexico, it apparently occurs at least as far south as Jalisco, Michoacan, and Guanajuato (Nelson, 1903; American Ornithologists' Union, 1957).

History of Discovery

The spotted owl was first observed by Xantus (1859), who collected a single specimen in 1858 near Fort Tejon in the southern Sierra Nevada Mountains. He named the new species "Syrnium occidentale" and called it the "California barred owl." The species was not reported again until 1872, when Bendire (1882) found a nest near Wipples Station, nine miles west of Tucson, Arizona. At the time, Bendire believed the nesting bird was a barred owl. He did not report this sighting until he realized his mistake nearly ten years later (Bendire, 1882).

The first record of the spotted owl in the Pacific Northwest was reported by Rhoads (1892) who described two specimens collected near Tacoma, Washington. Merriam (1898) subsequently observed several other specimens from Washington and, on the basis of plumage color, listed the spotted owl from the Pacific Northwest as a new subspecies, the northern spotted owl (Syrnium occidentale caurinum). Shortly thereafter, Nelson (1903) described a specimen from Mexico and, based on its very pale plumage color and extensive amount of white spotting, assigned it to a new subspecies, the Mexican spotted owl (Syrnium occidentale lucidum). To conform with the international system of zoological nomenclature, the species name was eventually changed to Strix occidentalis and the subspecific names were shortened to their present form.

After the initial observations described above, spotted owls were seen or heard occasionally at locations scattered throughout the range of the species. However, no effort was made to systematically inventory the population, and as a result, the species remained largely unknown for many decades. A few nests were found (e.g.; Bent, 1938; Dickey, 1914; Dunn, 1901; Ligon, 1926; Peyton, 1910) and a little information on food habits

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[2/] Personal communication, G. Gould, California Department of Fish and Game, Sacramento, California.

was obtained (e.g., Huey, 1932; Marshall, 1942, 1957) but, for the most part, the species was infrequently observed and was considered rare or uncommon. This began to change in the early 1970's, when a series of studies was initiated to determine the distribution and abundance of the spotted owl (Forsman, 1976, 1980, 1981a; Forsman and others, 1977, 1984; Garcia, 1979; Gould, 1974, 1975, 1977, 1979, 1985; Marcot and Gardetto, 1980; Postovit, 1977). These studies revealed that the spotted owl was fairly common in forested habitats throughout much of its range. These studies also indicated that, at least in the northern portion of the range of the species, spotted owls show a strong affinity for older forests and are declining in numbers as such forests are harvested and converted to intensively managed second-growth stands (Forsman and others, 1977, 1984; Gould, 1974, 1985; Postovit, 1977). In response to these initial finings, numerous studies have been started in recent years to investigate the relationships between spotted owls and their habitat.

CURRENT LEGAL STATUS AND POPULATION ESTIMATES

Federal Status

The northern spotted owl is not on the Federal list of threatened or endangered species (U.S. Fish and Wildlife Service, 1982). However, the Mexican subspecies is currently on the list of candidates for threatened or endangered species status (United States Federal Register, 1985). The spotted owl is classified as a migratory bird species (Title 50 Code of Federal Regulations 10.13). This means that it cannot be killed or captured without authorization from the U.S. Fish and Wildlife Service, (U.S. Fish and Wildlife Service, 1982).

Status in the State of California

The California Department of Fish and Game has classified the spotted owl as a "species of special concern" (Gould, 1985). This designation does not carry any special legal status, but is intended to draw attention to populations that have declined severely or that are otherwise so low that extirpation is a real possibility (Gould, 1985).

Gordon Gould of the California Department of Fish and Game has provided a series of updates on the numerical status of the spotted owl in California (Gould, 1974, 1975, 1977, 1979, 1985). As of October 1985, he reported that spotted owls had been located at 1,463 sites in the state, including 772 sites within the range of the northern spotted owl, 577 sites in the Sierra Nevada Mountains, and 114 sites in the coastal mountains of southern California. The total population in the state is unknown. Based on declining occupancy rates of sites known to have been occupied by spotted owls in the past, Gould (1985) estimated that the population in California declined by 4.5 percent during the ten-year period from 1974 to 1983.

Status in the State of Oregon

The Oregon Department of Fish and Wildlife has classified the spotted owl as a threatened species. In 1975, the State Directors of the Bureau of Land Management (BLM) and the Oregon Department of Fish and Wildlife signed an agreement under the Sikes Act in which the BLM agreed to provide adequate protection to wildlife species that were listed as threatened or endangered by the Oregon Department of Fish and Wildlife. According to the National Forest Management Act Planning Regulations 36 CFR 219, the USDA Forest Service is also required to recognize state-listed species, at least for planning purposes. The Oregon Forest Practices Act of 1971 requires that the State Department of Forestry give "special consideration" to wildlife species that are classified as rare or endangered by the Oregon Department of Fish and Wildlife.

As of 1980, spotted owls had been located at 636 sites in Oregon, (Forsman and others, 1984). By 1984, the number of sites where owls had been reported had increased to approximately 1,500 (Forsman, Oregon Department of Fish and Wildlife; unpublished data). The large increase in the number of known owl sites between 1980 and 1984 was mainly due to an increased effort on the part of USDA Forest Service and BLM biologists to inventory the owls. The total population of spotted owls in Oregon is unknown. The most recent update of inventory data indicates that earlier estimates of a population of 1,000 to 1,200 pairs in the state (Forsman and others, 1984:53; Carleson and Haight, 1985) were underestimates.

Based on a sample of 98 pairs of owls observed during a seven-year period (1972-1978), Forsman and others, (1984:17-18) estimated that the population in Oregon was declining at the rate of 0.8 percent per year. During the writing of this review, however, it was noticed that the rate of decline as quoted by Forsman and others (1984) was incorrect. The actual rate of decline should have been 1.1 percent per year, not 0.8 percent.

Status in the State of Washington

The Washington Department of Game presently lists the spotted owl as a "threatened" species (Washington Department of Game, 1983). The total population of spotted owls in Washington is unknown. The data base of owl records is presently being updated, so an exact count of all sites where spotted owls have been observed is not available. A preliminary review of the data suggests, however, that spotted owls have been reported from approximately 300 sites in Washington.[3/]

Status in the Province of British Columbia

The spotted owl is classified as a non-game bird in British Columbia and is protected against being killed or captured (U.S. Fish and Wildlife Service,

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3/ Personal communication, T. Owens, Washington Department of Natural Resources, Olympia, Washington.

1982). All indications are that the spotted owl is quite rare in British Columbia (Howie, 1980; Campbell and Campbell, 1984). During a recent survey conducted by the Ministry of Environment, spotted owls were found at only six sites in the province.[4/]

HOME RANGE CHARACTERISTICS

Marshall (1957:78) reported that pairs of spotted owls "range over a large area of about one-square mile in a single night." He apparently estimated the size of nightly foraging areas based on where he heard owls calling, as he did not have access to radiotelemetry techniques.

Since 1975, considerable data has been collected on the home range characteristics of spotted owls (Barrows, 1980; Forsman, 1980, 1981a; Forsman and others, 1984; Gutierrez and Sisco, 1984; Solis, 1983). Additional studies on home range characteristics are in progress in Oregon and Washington, and another, as yet unpublished, study has recently been completed in the Sierra Nevada Mountains of California.[5/] Following is a summary of the information that has thus far been made available for public review.

Forsman (1980, 1981a) and Forsman and others (1984) described two separate studies in which radiotelemetry techniques were used to examine home range characterisitics and habitat use by spotted owls in Oregon. During the first of those studies (May 1975 to May 1976), a sample of eight adult owls was observed in the Cascade Range for periods ranging from 271 to 383 days. During the second study (April to September 1980), a sample of six adults was observed in the Coast Ranges for periods ranging from 111 to 138 days. The 14 adults that were observed in these two studies included six pairs (both members of each pair were marked) and two females that were paired, but whose mates were not marked. One of the marked pairs and the two marked females with unmarked mates nested during the study.

The home ranges of the 14 adults averaged 4,349 acres per bird (minimum = 1,394 acres, maximum = 8,584 acres). The size of the home range generally increased during winter. Home ranges of paired individuals overlapped by 40 to 93 percent (average = 68 percent), and home ranges of owls holding neighboring territories overlapped by 3 to 25 percent (average = 12 percent). The total area used by individual pairs of owls averaged 6,614 acres (minimum = 2,840, maximum = 10,440 acres). Although the differences were not statistically significant, individuals occupying heavily cutover areas had larger home ranges on the average than did individuals occupying relatively undisturbed areas. Forsman and others (1984) emphasized that the six owls that were observed in heavily disturbed areas were observed

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4/ Unpublished data on file, British Columbia Ministry of Environment, Vancouver, British Columbia.

5/ Personal communications, L. Brewer, Washington Department of Fish and Game, Olympia, Washington; E.C. Meslow, Oregon Cooperative Wildlife Research Unit, Corvallis, Oregon; and S. Laymon, Department of Forestry and Resource Management, University of California, Berkely, California.

for shorter periods than the owls that were observed in relatively undisturbed habitats.

Solis (1983) and Sisco and Gutierrez (1984) conducted a two-part study of the use of home ranges and habitat. The sample consisted of ten radio-tagged owls (seven adults and three juveniles) located in northwestern California. Solis' observations were limited to the spring and summer months of 1980 and 1981. In two cases, Solis was able to radio-tag both members of a pair and thus was able to collect information on the combined home range areas of the paired individuals. One of these pairs was subsequently studied by Sisco and Gutierrez during the fall and early winter (October to December) of 1981. They observed a subset of the same owls that had been radio-tagged and observed by Solis.

The results of these two studies are summarized as: home range size of the seven adults averaged 1,594 acres (minimum = 600, maximum = 3,301 acres). The two home range areas used by the pairs that were observed were 1,258 and 2,883 acres. Home range areas increased during the winter months. During the summer months, home ranges of paired individuals overlapped by 40.9 to 69.6 percent (average = 62 percent), and home ranges of neighboring owls overlapped 2 to 99 percent (average = 39 percent).

The studies of home range characteristics conducted by Forsman and others (1984), Sisco and Gutierrez (1984), and Solis (1983), are not directly comparable because tracking periods and the number of observations per owl were considerably different. These differences could account for at least some of the variation in size of home ranges, both within and among studies.

Laymon (1985) described a three-year study in which he radio-tagged a sample of 13 adult and 12 juvenile spotted owls in the Sierra Nevada Mountains. Specifics of the size of home ranges and the use of habitat by the individual marked adults are, as yet, unavailable for review. However, Laymon did report that four of the radio-tagged adults migrated downhill during the fall and wintered at lower elevations. Straight-line distances between the nest areas and wintering areas used by these individuals ranged from 12 to 20 miles. The following spring, all four of the migratory individuals returned to the nesting areas that they had occupied the previous year.[6/] Similar migratory behavior has been observed in a study that is currently underway in Washington State. In the latter study, however, individuals did not consistently migrate to lower elevations during the winter.[7/] No such seasonal movement has been observed in Oregon.

6/ Personal communication, S. Laymon, Department of Forestry and Resource Management, University of California, Berkeley, California.

7/ Personal communication, L. Brewer, Washington Department of Game, Olympia, Washington

HABITAT

General Attributes of Habitat

Characteristics of habitats occupied by spotted owls have been described by many authors (e.g., Barrows, 1978, 1980, 1981; Barrows and Barrows, 1978; Bent, 1938; Dickey, 1914; Forsman, 1976, 1980, 1981a; Forsman and others, 1984; Garcia, 1979; Gould, 1974, 1977, 1979, 1985; Ligon, 1926; Marcot, 1978; Marcot and Gardetto, 1980; Marshall, 1942, 1957; Paz and others, 1979; Postovit, 1977; Solis, 1983; Sisco and Gutierrez, 1984). Stands occupied by spotted owls tend to be dominated by coniferous trees in British Columbia, Washington, and northwestern Oregon, and by mixtures of conifers and hardwoods in southwestern Oregon and California (Garcia, 1979, Forsman and others, 1984; Solis, 1984; Sisco and Gutierrez, 1984; Gould, 1974). Forsman and others (1984) reported that, except for subalpine forests and monospecific forests of ponderosa pine, lodgepole pine, and Sitka spruce, spotted owls were found in virtually all of the major coniferous forest associations that occurred in western Oregon and on the east slope of the Cascade Mountains.

In Oregon, the upper limits in elevation of the species range generally correspond with the ecotone that is between mid-elevation forests and subalpine forests. Maximum elevations at which spotted owls occur tend to increase from north to south within the species' range, reflecting the gradual latitudinal changes that occur in vegetation and climate (Forsman and others, 1984; Gould, 1974).

Forsman and others (1984) reported that 98 percent of the sites in Oregon, where spotted owls were located between 1969 and 1980, were dominated by old-growth forests or by mixed stands of old-growth and mature forest. They defined old-growth forests as stands in which the dominant overstory trees were over 200 years old and mature forests as stands in which the dominant overstory trees were between 100 and 200 years old. If the sites analyzed by Forsman and others (1984) are combined with the large number of sites located in Oregon since 1980, the portion of sites in old growth or old-growth and mature forests is approximately 93 percent.[8/] The remaining 7 percent of the sites were found in stands that were dominated by trees that were 36 to 99 years old. Many of the latter stands included residual pockets of old-growth conifers that were interspersed among the younger trees.

The preponderance of owl locations in older forests suggests that spotted owls strongly prefer such forests in Oregon (Forsman and others, 1984). Preference for older forests was also indicated by a study in which Forsman and others (1977) found that, in Oregon, spotted owls were roughly 12 times more abundant in old-growth forests than in young second-growth forests. The situation with respect to habitat preference appears to be similar in Washington State (Postovit, 1977; Garcia, 1979) and northwestern California (Gould, 1974; Marcot, 1979, Marcot and Gardetto, 1980; Solis, 1984, Sisco

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8/ Unpublished data on file, Oregon Department of Fish and Wildlife Northwest Regional Office, Corvallis, Oregon.

and Gutierrez, 1984).[9/] In the southern Sierra Nevada Mountains and coastal mountains of southern California, however, the relationship between spotted owls and old-growth forests becomes less consistent. In fact, many pairs in the coastal mountains of southern California occupy forests that are dominated by evergreen hardwood forests or pine-oak woodlands in which few, if any, old-growth trees are present.[10/]

Foraging Habitat

All 14 of the adult owls studied by Forsman and others (1984) showed a significant preference for foraging in unlogged old-growth forests. Expected values were based on the availability of types of cover. Actual use of cover types by the owls was statistically compared to the availability of cover types. Use of old-growth forests that had been selectively logged was either not significantly different than expected or significantly less than expected, suggesting that, at least in forests of Douglas-fir and western hemlock, selective logging decreased the suitability of old-growth stands for foraging.

Use of older second growth and mature forests (61 to 200 years old) was variable, ranging from significantly less than was expected in most cases to significantly more than expected in a few cases. Use of young second growth forests (25 to 60 years old) was, in all cases, significantly less than or not significantly different than expected. Areas that had been clearcut or burned within the previous 20 years were rarely used for foraging. Selection of habitat for foraging did not change appreciably on a seasonal basis.

Seven adults studied by Solis (1983) showed a significant preference for foraging and roosting in old-growth and mature forests. Solis did not discriminate between old-growth and mature forests and combined his foraging and roosting data for analyses of preference. Stands consisting of small to medium-sized trees (5 to 15 inches in diameter) were used significantly less than expected by all seven adults, indicating that younger stands provided less suitable foraging habitat than mature or old-growth stands. Although the small size of his sample precluded testing for preference of early successional types of cover (the brush/seedling/sapling stages), Solis reported that owls rarely used areas covered by those types of vegetation.

Based on a multivariate analysis, Solis (1983) and Sisco and Gutierrez (1984) concluded that it was possible to discriminate between foraging and roosting habitat and between habitats used by males and females. Discrimination between habitats used during the summer and winter was less successful, however. The authors suggested that the larger size and higher

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9/ Personal communication, L. Brewer, Washington Department of Fish and Game, Olympia, Washington.

10/ Personal communication, G. Gould, California Department of Fish and Game, Sacramento, California.

wing loading of females were factors in differential use of habitat by males and females.

Soils reported that variables that consistently differentiated between foraging and roosting sites were: (1) canopy closure; (2) density and basal area of trees that were 5 to 11 inches in diameter and trees that were greater than 35 inches in diameter; (3) elevation; (4) aspect; and, to a lesser extent, (5) ground cover by herbs and state of decay of snags. Variables that best differentiated between habitats used by males and females were: (1) state of decay of snags; (2) density and basal area of trees that were 5 to 11 inches diameter breast height (dbh) or greater than 35 inches dbh; and (3) elevation. Compared to males, females tended to use stands at lower elevations and that had: (1) more snags in advanced stages of decay; (2) lower density and basal area of small trees; and (3) higher density and basal area of large trees. Solis suggested that segregation of the sexes by their differing use of foraging habitats might be a result of size dimorphism. Male spotted owls tend to be smaller than females (Earhart and Johnson, 1970).

Fall and winter observations on a subset of the same owls observed by Solis (1983) indicated that, during the fall and winter, most of the owls used stands of old-growth/mature forest and medium-sized trees either more than expected or in proportion to occurrence (Sisco and Gutierrez, 1984:85). This would suggest an increase in the use of stands of medium-sized trees during the fall and winter, since all owls used such stands less than expected during the summer (Solis, 1983:40). Young seral stages, which include saplings, brush, grass, and forbs, were generally avoided during the fall and winter except that use of such areas by one owl did not differ from expected. Use of stands that had been selectively harvested increased somewhat during the fall and winter.

Amount of Old-Growth Forest Within Foraging Areas

The size of the total home range has already been discussed. The amount of old-growth forest within the home ranges of the individual owls observed by Forsman and others (1984) averaged 1,686 acres (minimum = 740, maximum = 2,295 acres) (Forsman, 1980, 1981a). The amount of old-growth forest within the home ranges of the six pairs of owls observed by Forsman and others (1984) averaged 2,264 acres (minimum = 1,008, maximum = 3,786 acres). The home range of a pair was defined as the sum of the individual home ranges of the male and female, counting those areas where home ranges overlapped only once. Again, it is important to remember that some of the owls observed by Forsman and others (1984) were observed only for three to four months during the spring and summer. Had these individuals been studied for longer periods of time it is likely that their home ranges would have increased in size and included larger areas of old-growth forest.

The amount of old-growth and mature forest within the home ranges of seven adult owls studied by Solis (1983) and Sisco and Gutierrez (1984) averaged 477 acres (minimum = 210, maximum = 990 acres). Again, it is important to emphasize that these figures probably underestimated the amount of

old-growth/mature forest within the home ranges of the owls. This is because most of the owls were observed for relatively short periods of time. In some cases, the observations were made only during the spring and summer months. The authors did not differentiate between old-growth and mature forests, so the above data represent the combined amount of old-growth and mature forest within the spring and summer home range. The amount of old-growth and mature forest within the home range of one of the pairs observed by Solis was 367 acres. The other pair, which was observed by both Solis and Sisco and Gutierrez (1984), occupied a home range encompassing at least 1,233 acres of old-growth and mature forest. The exact amount of old-growth and mature forest within the home range of the latter pair was unclear. Sisco and Gutierrez reported that the home range of this pair increased during the winter, but did not specify the acreage of mature and old-growth forest encompassed by the winter home range.

Roosting Habitat

Forsman and others (1984) located 1,653 spotted owl roosts, including 645 that were located visually by homing in on radio-tagged owls and 1,008 that were located remotely by triangulation of radio signals. Over 90 percent of these roosts were in old-growth conifer forests, indicating that such forests were strongly preferred for roosting. The type of roost tree used and the position of the perch within the forest canopy were influenced by weather conditions. During warm or hot weather, the owls tended to roost low in the forest understory in small trees or shrubs where they were protected from high temperatures. Most of the roosts used during warm or hot weather were in hardwood trees (especially vine maple and Pacific dogwood) or in small western hemlock trees. In contrast, owls roosted significantly higher in the forest canopy during cold or wet weather and tended to roost in large old-growth conifers. When it was raining, owls often roosted close against the trunk on the underside of a leaning tree or under a protective cover of large limbs. Forsman and others (1984:54) hypothesized that old-growth forests were preferred for roosting because such forests provided the most protective environment for roosting under most weather conditions. They did not, however, test this hypothesis.

Barrows and Barrows (1978) and Barrows (1980, 1981) described the roosting behavior and roost site characteristics of spotted owls at several sites in northwestern California and the coastal mountains of southern California. They described a total of 15 heavily-used roost sites and an undisclosed number of roosts that were used less frequently. Their data indicated that, during warm or hot weather, spotted owls selected cool, shady roosts in the forest to avoid exposure to high temperatures and direct sunlight. Stands used for roosting were typically multi-layered, with an overstory of Douglas-fir or Douglas-fir and coast redwood, and an understory of hardwoods (consisting of tanoak, California bay, buckeye, and coast live oak). The age of stands used for roosting was not discussed. Although the owls observed by Barrows (1981) frequently roosted near water, it was not clear if selection was made for the nearby source of water or for the dense stands that tended to develop in ravines near water, or both. The authors emphasized that all heavily used summer roosts were on north aspects.

Solis (1983) located 397 spotted owl roosts of which 98 were visually located and 299 were located remotely by triangulation. Solis' observations were conducted during the summer, so his results tended to reflect the selection of roost sites during fair weather. He reported that roosts were typically found "in hardwoods of the understory, which provided dense overhead and side closures, on the lower one-third of north-to-east facing slopes, and near water." His data are not fully supportive of this statement, however, in that 29 percent of the roosts were on southerly aspects and 41.1 percent of the roosts were on the middle third of the slope. Total canopy closure in the roosts examined by Solis averaged 86.7 percent (minimum = 64 percent, maximum = 98 percent). Solis further reported that temperatures in roost areas averaged 4.8°C (8.6°F) cooler than in nearby areas lacking a tree canopy, and that perch height showed a significant negative correlation with ambient temperature. Variables having the greatest influence on selection of habitat for roosting were height of trees, lateral, and overhead closure of roost trees, aspect, distance to water, and total canopy closure (Solis, 1983:55). Differences in habitat selected for roosting and foraging that were noted in Solis' study have already been discussed under "Foraging Habitat."

Sisco and Gutierrez (1984) observed 25 spotted owl roosts during the fall and winter months. In most respects, the results reported by Sisco and Gutierrez are similar to the results of Forsman and others (1984). In both studies, it was noted that roost height was negatively correlated with temperature and that the owls sought protection from precipitation by roosting close against the trunks of large trees. In both studies it was also noted that the use of conifers as roost trees increased during cold, wet weather. A factor analysis that was conducted by Sisco and Gutierrez indicated that the variables that best explained differences between summer and winter roosts were perch height, distance between the owl and the trunk of the perch tree, height of the overstory and understory trees, aspect of the slope, position on the slope, and weather conditions.

Nesting Habitat

Forsman and others (1984) described 47 nests located in Oregon. Of these nests, 42 were located in old-growth conifer forests (stands over 200 years old), and five were in younger stands (70 to 140 years old) that had residual old-growth trees scattered among the younger trees. Canopy closure was measured at 26 of these sites and averaged 69 percent (minimum 35 = percent, maximum = 91 percent, standard error = 2.65). Nests were found on slopes ranging from 0 to 85 percent. Over half the nests (57 percent) were found on the lower half of hillsides. There was no significant preference for nesting on any particular aspect. Most nests (84 percent) were within 820 feet of a stream or spring. It was not determined if this reflected a preference for nesting near water.

Although a few nests have been found in Washington, they have not been described in the literature.[11/] Smith (1963:440) reported that a nesting

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11/ Personal communication, H. Allen, Washington Department of Game, Olympia, Washington.

pair in southwestern British Columbia was observed in a "mature" stand of western hemlock, western red cedar, Douglas-fir, Engelmann spruce, and silver fir.

In southern California and the southwestern United States, spotted owls often nest in rugged, rocky mountains or canyons, where pine-oak woodlands or forests of evergreen hardwoods predominate (Bent, 1938). Cliffs and caves are often abundant in such areas and provide an alternative nesting environment for spotted owls (Dickey, 1914; Ligon, 1926; Bent, 1938). Observations by Dickey (1914), Ligon (1926), and Bent (1938), suggest that selection for a cool nesting microenvironment, such as that found in caves, north-facing slopes and narrow canyons, may be more pronounced in southerly latitudes, where owls are subjected to higher temperatures during the spring and summer. A study of the characteristics of spotted owl nest sites in northwestern California is currently in progress.[12/]

REPRODUCTIVE BIOLOGY

Nests

Characteristics of nests used by spotted owls have been described by numerous authors (e.g., Bendire, 1882; Dunn, 1901; Peyton, 1910; Dickey, 1914; Ligon, 1926; Bent, 1938; Forsman and others, 1984). The types of nests that are used differ from region to region. To a large extent, these variations are probably due to regional differences in habitats as described below.

Spotted owls nest in pre-existing cavitites or platforms that either develop naturally or are built by other birds or mammals (Forsman and others, 1984). References that appear in the literature concerning nest building by spotted owls resulted from cases in which early naturalists saw spotted owls using platform nests and assumed that the owls had built these platforms (Bendire, 1882; Heller, 1873).

Pacific Northwest

All nests that were reported from the Pacific Northwest have been located in cavities or platforms in trees, mostly in Douglas-fir (Forsman and others, 1984). Most cavity nests in this region have been located in stovepipe-shaped cavities that form when the tops of an old-growth conifers snap off, exposing the hollow interior of the trunks. These cavities tend to be sheltered from above by one or more secondary tops that develop after the original crown of the tree is broken. Nests in cavities that developed in tree trunks where the branches rip loose from the trunk are less frequently found. Although most cavity nests are in living trees, dead trees (snags) are used occasionally. Cavity nests in this region are rarely located in hardwood trees. Height above the ground of 47 nests in

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12/ Personal communication, R. Gutierrez, Humboldt State University, Arcata, California.

Oregon averaged 88.5 feet (minimum = 33.0, maximum = 182.6, standard error = 34.56).

Approximately 50 percent of all nests used by spotted owls in southwestern Oregon and on the east slope of the Cascade Range in Oregon were in platforms in trees (Forsman and others, 1984). A variety of platform types was used, including stick nests built by other birds or mammals and platforms that developed naturally when twigs and other debris collected on top of limbs. Platforms in conifers that were heavily infected by dwarf mistletoe (Arceuthobium ssp.) appeared to be especially attractive as nest sites.

Southern California

Most nests that were reported from southern California have been located in cavities or platforms in trees, or on ledges or in potholes in cliffs (Heller, 1873; Dunn, 1901; Peyton, 1910; Dickey, 1914; Bent, 1938). Cavity nests in this region are often located in natural hollows in hardwood trees (Dunn, 1901). There are two old records of spotted owls nesting on the ground in this region (Norris, 1886; Lillie, 1891). Bryant (1940) reported an instance in which a pair may have nested in a hollow log in the southern Sierra Nevada Mountains. It was unclear, however, whether this pair nested in the log or whether their young were simply using the log as a roost site after they had left the nest.

Southwestern United States and Mexico

In this region, few nests have been described. Bendire, 1882, 1892, described two nests from Arizona. One was a stick platform in a cottonwood tree and the other a large cavity in an oak tree. Ligon (1926) described three nests in New Mexico, including two nests on ledges in caves and one in a platform in a dense cluster of limbs in a Douglas-fir that was infected with dwarf mistletoe. Ligon emphasized the fact that the nests he found in caves were in perpetual shade. Shade may play an important role in the selection of nest sites, especially in the southwestern United States and Mexico, where daytime temperatures in the 90° to 110°F range are not uncommon.

Nesting Behavior

Nesting behavior of spotted owls has been described by a number of authors, including Dickey (1914), Ligon (1926), Bent (1938), Miller (1974), and Forsman and others (1984). Unless otherwise noted, the following description of reproductive behavior is summarized from Forsman and others (1984).

Nesting pairs typically begin to roost together near their nest sites in February or March, two to three weeks before the eggs are laid. Soon after they begin to roost together, they begin a nightly ritual in which they copulate and display near the nest. Copulation is usually followed by a

display in which one or both of the pair call from a perch near the nest. Eggs are laid in March or early April at three-day intervals. In Oregon, the mean date that clutches were started was 2 April (sample size = 21, range = 9 March to 19 April). Bent (1938) reported 15 clutches that were collected or observed in California between 1 March and 10 May. He estimated that the "height of the laying season" was 27 March to 1 April. It should be noted that the dates given by Bent indicate when clutches were found, which is not always an accurate indication of when the eggs were laid. It is possible that some of these clutches were laid days or even weeks before they were found. Nevertheless, the date presented by Bent (1938) indicate a mean date of clutch initiation similar to the dates reported from Oregon.

Bent (1938:204) reported that, "The spotted owl lays two or three eggs, usually only two, and very rarely four...." Clutches or broods of four have been reported only two times since the discovery of the species, indicating that such occurrences are, indeed, extremely rare (Bendire, 1982; Dunn, 1901). Forsman and others (1984) reported that clutch size was two in each of four nests that were examined in Oregon. In lieu of information on the clutch-size at most nests, Forsman and others used the number of young leaving the nest as an index of minimum clutch-size. The mean number of young produced per successful nest during the study was 2.0 suggesting that two may be the usual number of eggs laid.

Based on observations at one nest, Forsman and others (1984) estimated the incubation period at 30 -/+ 2 days. Zarn (1974:10) suggested that the incubation period might be 20 to 28 days, but had no data to support this estimate.

Females alone incubate the eggs and brood the young. Males provide food for the female and young until the young are approximately two weeks old, at which time females begin to assist with foraging. Most young spotted owls leave the nest between the middle of May and the end of June when they are approximatly 35 days old. Their flight feathers are only partially developed when they leave the nest. Many owlets, therefore, fall to the ground when they jump from the nest. After leaving the nest, some owlets may continue to roost on the ground for several days, but most are soon able to climb or fly into elevated perches.

After they leave the nest in May or June, owlets are fed by their parents until late August or early September. During this period, most broods remain within a few hundred meters of the nest. However, some broods may wander up to 1.5 km from the nest prior to beginning dispersal (Forsman and others, 1984:37; Gutierrez and others, 1985:5).

Owlets undergo a series of molts in their first summer. The pure-white natal down is replaced by the downy juvenile plumage while the owlets are still in the nest. The juvenile plumage is then gradually replaced during the summer by the Basic I plumage. With the exception of the tail feathers, this plumage appears to be indistinguishable from the adult plumage. Juvenile tail feathers are sharp-pointed and have a pure-white terminal band, whereas tail feathers acquired in subsequent molts are more rounded and the terminal band is mottled with brown (Forsman 1981b). The

juvenile tail feathers are not molted until young owls are approximately 26 to 27 months old, and can, therefore, be used to distinguish young owls from older birds.

DEMOGRAPHICS

Annual Variation in Reproduction

Reproduction by spotted owls fluctuates dramatically from year to year. In some years most pairs may breed, whereas in other years very few pairs even attempt to nest (Table 1). These reproductive fluctuations do not seem to follow a predictable cycle. It has been suggested that fluctuations in reproduction may be related to fluctuations in prey availability (Forsman and others 1984; Barrows, 1985; Gutierrez, 1985). However, no one has as yet done an adequate job of sampling the prey of the spotted owl to statistically document a relationship between fluctuations in reproduction and abundance of prey.

Age at Reproductive Maturity

The age at which most spotted owls first breed is poorly documented. There are two published records of individuals that nested as two year olds (Barrows, 1985; Miller and others, 1985). However, the rarity of sightings of breeding birds that are less than three years old indicates that most individuals do not breed until they are at least three years old. For purposes of demographic calculations, Lande (1985) assumed that spotted owls first breed as two year olds.

Adult Survivorship, Mortality Rates, and Longevity

Little quantitative data is available on adult survival rates or longevity. However, observations of radio-tagged adults indicate that adult mortality rates are low and that adults are relatively long lived (Forsman and others, 1984; Solis, 1983; Sisco and Gutierrez, 1985). Based on the survival rates of radio-tagged adults in Oregon and northwestern California, Barrowclough and Coats (1985) and Lande (1985) estimated that the annual adult survival rate was 0.85.

Juvenile Survivorship

Forsman and others (1984) observed 29 owlets during the first summer of life and found only 65 percent of them were still alive by the end of August. Radiotelemetry studies of dispersing juveniles indicate that juvenile mortality is high, both prior to and during dispersal. In fact, it is so high that attempts to study dispersal in the spotted owl have been only marginally successful because most of the dispersers have died or been lost. For example, Meslow (1985) reported that, of 31 recently fledged juveniles that were radio-tagged in Oregon between 1982 and 1984, none survived as long as two years. Similar results were reported by Gutierrez

and others (1985a, b), Miller and Meslow (1985), Laymon (1985), Laymon and Barrett (1985). Accurate estimates of juvenile survival rates are difficult to compute from the above dispersal studies because the fate of many marked individuals was not determined. Based on unpublished data collected in northwestern California by Gutierrez and others, Barrowclough and Coats (1985) estimated that juvenile survivorship during the first year of life was 0.19. Lande (1985) estimated that a first year survival rate of 0.44 would be required to maintain a stable population of spotted owls.

The large discrepancy between the survival rate that was estimated from field data and the estimated survival rate required for maintenance of a stable population could have several explanations. It is possible that the estimates of fecundity, adult survivorship, and age at first breeding that Lande (1985) used in his model are grossly inaccurate. Except for age at first breeding which should probably be changed to three years, rather than two, it is unlikely he used grossly inaccurate estimates. An increase in the age at first breeding would require even higher juvenile survivorship to maintain a stable population.

It is also possible that the observed survival rates are accurate, in which case the differences between the observed and predicted rates are the result of a declining population (Lande, 1985). That the population is declining has already been documented by Forsman and others (1985) and Gould (1974, 1985). However, the rates of decline described by Forsman and Gould were not nearly as rapid as the rate predicted by Lande based on demographic modeling.

Another explanation is that the data that have been collected on juvenile survivorship during dispersal are atypical. The years that Gutierrez and others (1985a,b), Miller and Meslow (1985), and Laymon and Barrett (1985) conducted their dispersal studies (1982, 1983, 1984) included two years in which few pairs nested. This could indicate a period of either reduced populations of prey or some other deleterious factor in which dispersing juveniles were subjected to extremely rigorous conditions.

Finally, it is possible that the radio transmitters that were used to observe the movements of juvenile owls reduced the mobility, foraging efficiency, or theromoregulatory efficiency of the owls, thereby making the marked individuals more susceptible to death by starvation or predation. This possibility has not been evaluated.

JUVENILE DISPERSAL

The dispersal of young spotted owls has been studied in Washington (Allen and Brewer, 1985a, b), Oregon (Forsman and others, 1984; Meslow, 1985; Miller and Meslow, 1985), and California (Gutierrez and others, 1985a, b; Solis, 1983; Laymon and Barrett, 1985). In these studies none of the young that were radio-tagged were successfully followed until they became a part of the breeding population. Most of the radio-tagged juveniles died during dispersal or were lost (Table C-2). Nevertheless, these studies did generate a considerable body of information on the behavior and habitat use of dispersing juveniles, as summarized below.

Most juvenile spotted owls abruptly leave their natal areas and begin to disperse in September or October (Forsman and others, 1984; Gutierrez and others, 1985a, b; Miller and Meslow, 1985; Laymon, 1985; Laymon and Barrett, 1985). Most individuals wander over extensive areas during their first winter. During a two-year study of juvenile spotted owls in northwestern California, Gutierrez and others (1985b) found that the maximum dispersal distance (the straight-line distance between the nest or location of the first sighting and the most distant location reached by the dispersing owl) ranged from 0.6 to 62 miles. Allen and Brewer (1985) reported that maximum dispersal distances sometimes exceeded 29.8 miles in Washington. Compared to established adults, dispersing juveniles do not appear to be particularly selective about the types of cover that they use for foraging and roosting (Gutierrez and others, 1985a, b; Allen and Brewer, 1985a, b). This may account, in part, for the high mortality rate of juveniles. It may also account for many of the winter sightings of spotted owls in inappropriate habitats. Such sightings are frequently touted as evidence that spotted owls do not need old-growth or mature forests.

Based on one year of data, Gutierrez and others, (1985a) suggested that dispersal on their study area was directional, with most young moving in a southerly direction. In the second year of their study, however, Gutierrez and others, (1985b) found that mean dispersal vectors (refer to Glossary) for individuals owls did not differ significantly from random. In other words, all owls taken together did not show a consistent propensity for dispersing in the same general direction. This conclusion is in agreement with Allen and Brewer (1985a, b) and Laymon and Barrett (1985).

Topographical barriers such as ridges and small rivers do not appear to significantly impede the movements of dispersing juveniles (Gutierrez and others, 1985b; Laymon, 1985). It has yet to be determined, however, if very large rivers such as the Columbia River are a serious barrier to dispersing juveniles.

TECHNIQUES FOR DETERMINING SEX AND AGE

Female spotted owls average slightly larger than males, but the weights and measurements of individual females and males overlap to such an extent that they are unreliable indicators of sex (Earhart and Johnson, 1970).

For an experienced observer, it is relatively easy to determine the sex of spotted owls by listening to the pitch of their vocalizations. Males generally have lower-pitched calls than females (Forsman and others, 1984). Because spotted owls can usually be stimulated to call during the day, as well as at night, determination of sex from vocalizations is effective day or night.

Barrows and others (1982) suggested that the number of complete horizontal bars on the two central tail feathers was a reliable indicator of the sex

of spotted owls, with males having fewer bars than females. However, data from Oregon indicate that this technique is not entirely reliable.[13/]

During their first summer, young spotted owls can be identified by their downy plumage. By September or October, juveniles lose all vestiges of their downy plumage and, except for the distinctively marked tail feathers previously described under "Nesting Behavior," they look like adults. The juvenile tail feathers are not molted until young owls are 26 to 27 months old, and thus, are a good character for identifying individuals that are less than 26 months old.

Vocalizations

Phonetic renditions of the more common vocalizations given by spotted owls have been described by many authors (Bent, 1938; Ligon, 1926; Maillard, 1927; Sumner and Dixon, 1953; Gould, 1974). Forsman and others (1984) presented sonograms of the most common vocalizations. Although Forsman and others reported that there was considerable individual variation in vocalizations, no detailed studies of individual or regional variation in vocalizations have been published.

COMPETITORS

Relationships between spotted owls and other species which might compete with them for resources or space have not been studied in detail. Some authors have expressed concern that the invasion of the barred owl into the range of the spotted owl may represent a significant competitive threat to the spotted owl (Taylor and Forsman, 1976; U.S. Fish and Wildlife Service, 1982; Gutierrez and others, 1984).[14/]

PREDATORS

Based on two instances of predation on juvenile spotted owls by great horned owls, Forsman and others (1984) suggested that the great horned owl was a major predator on juvenile spotted owls. Other instances of predation on juvenile spotted owls by great horned owls have been documented in recent studies in Oregon.[15/] Ravens, goshawks, Coopers hawks, and red-tailed hawks have also been listed as potential predators on spotted owls (Forsman and others, 1984).

13/ Unpublished data, Eric Forsman, 580 S.E. Corliss Avenue, Corvallis, Oregon.

14/ Personal communication, H. Allen, Washington Department of Game, Olympia, Washington.

15/ Personal communication, G. Miller, Oregon Cooperative Wildlife Research Unit, Corvallis, Oregon.

ENVIRONMENTAL CATASTROPHIES

Chance environmental events such as fire, windstorms, and disease have a considerable impact on the habitat of spotted owls. In 1980, for instance, the eruption of Mount St. Helens leveled approximately 25,000 acres of mature and old-growth forest on the Gifford Pinchot National Forest in Washington, eliminating an undetermined number of pairs of spotted owls in the process (Ruediger, 1985). A windstorm in December 1983 leveled approximately 6,000 acres of mature and old-growth forest in the Bull Run Watershed on the Mount Hood National Forest.[16/] This area was known to contain a high density of spotted owls. The Oxbow Fire, which occurred in the Oregon Coast Range in 1966, burned over 43,000 acres of forest land, including a considerable amount of old-growth forest.

To counteract the loss of habitat caused by chance environmental events such as those described above, Ruediger (1985) emphasized that management of old-growth forests for spotted owls must be dynamic rather than static. He suggested that more than a minimum number of sites be managed for spotted owls, so that substitute sites would be available in the event that some sites are destroyed by chance environmental events.

DIET

Spotted owls feed on a variety of mammals, birds, reptiles, and insects, but mammals make up the bulk of the diet (Barrows, 1978, 1985; Beebe and Schonewald, 1977; Bent, 1938; Earhart and Johnson, 1970; Forsman and others, 1984; Huey, 1932; Kertell, 1977; Ligon, 1926; Marshall, 1942, 1957; Snyder and Wiley, 1976; Wagner and others, 1982). Most foraging occurs at night; therefore, most of the prey are nocturnal animals. However, some foraging does occur during the day, especially when owls are raising young (Miller, 1974).

The composition of the diet varies by region and season. The following discussion summarizes what is known about the diet in different geographical regions.

British Columbia and Washington

Little quantitative information is available on the diet of spotted owls in this region. Flying squirrels (_Glaucomys sabrinus_) and deer mice (_Peromyscus maniculatus_) predominated in a small sample of pellets collected in southwestern British Columbia (Table 3, Smith, 1963).

16/ Personal communication, D. Longrie, Mt. Hood National Forest, Gresham, Oregon 97030.

Oregon

Forsman and others (1984) described the diet of spotted owls in Oregon based on a sample of 4,527 prey items that were identified in pellets collected between 1970 and 1980. In the humid forests of northwestern Oregon, the northern flying squirrel was the most abundant animal in the diet. Other important prey items in northwestern Oregon included red tree voles (Phenacomys longicaudus), deer mice, western red-backed voles (Clethrionomys occidentalis), woodrats (Neotoma spp.), and juvenile hares and rabbits (Table C-3).

In the mixed conifer forests of southwestern Oregon, woodrats were the most abundant prey in the diet, constituting 39 percent of the prey taken and 70 percent of the biomass consumed. Northern flying squirrels were the second most common prey in the diet (Table C-3).

California

The diet of spotted owls in the mixed conifer forests of northwestern California is very similar to the diet of owls occupying similar forests in southwestern Oregon (Table C-3) (Barrows, 1978, 1985; Solis, 1983). Woodrats are the dietary mainstay, but flying squirrels, red tree voles, and deer mice are also commonly taken.

Data from the coastal ranges of central and southern California indicate that woodrats and deer mice are the primary prey in this region (Barrows, 1980; Beebe and Schonewald, 1977). In the Sierra Nevada Mountains, flying squirrels and woodrats are abundant animals in the diet, but a variety of other prey are taken, including bats, insects, birds, and western gray squirrels (Sciurus griseus) (Laymon, 1985; Marshall, 1942) (Table C-3).

Southwestern United States and Mexico

The limited information that is available on the diet of spotted owls living in this region indicates that woodrats make up the bulk of the diet, both in terms of numbers and biomass (Kertell, 1977; Marshall, 1957; Wagner and others, 1982). Seven prey items reported by Kertell (1978) in Zion National Park included five woodrats, a gopher, and a beetle. Wagner and others (1982) examined a sample of 105 prey items from Capitol Reef National Park in southern Utah and found that woodrats and mice (Peromyscus spp.) made up 72.4 and 15.2 percent of the diet, respectively. Stomachs of several spotted owls collected by Marshall (1957) and Huey (1932) were filled with nocturnal insects, indicating that insects are important in the diet during the summer months in Arizona and Mexico.

HISTORY OF MANAGEMENT EFFORTS

Oregon

The first attempt to formulate a spotted owl management plan was initiated by the Oregon Endangered Species Task Force in 1973. This group, which

included representatives from the U.S. Fish and Wildlife Service, Oregon Department of Fish and Wildlife, USDA Forest Service, BLM, and Oregon State University, was formed in 1973 at the request of the State Director of the Oregon Department of Fish and Wildlife. The primary charge to this group was to develop and coordinate management plans for sensitive or endangered species that occurred over broad geographic regions within the state. One of the first actions of this Task Force was to appoint a subcommittee with instructions to develop a draft management plan for the spotted owl in Oregon.

At the outset, the Spotted Owl Subcommittee agreed that the objective of the spotted owl management plan should be to maintain a viable population of owls. To achieve this end, the Committee recommended that a system of uniformly spaced owl management areas be established throughout the range of the species in Oregon (Oregon Endangered Species Task Force 1977). Recommended spacing between management areas was three to 12 miles. To accomplish the desired spacing, the committee recommended that 400 pairs of owls were needed in Oregon. It was further recommended that each pair be provided with a core area of at least 300 acres of old growth centered on the known or suspected nest area. In addition, 900 acres of forest habitat surrounding the core was to be managed such that, at any one time, at least 50 percent of the area was covered by forests that were at least 30 years old.

In 1977, the Oregon Spotted Owl Management Plan was submitted to the Regional Forester of the Pacific Northwest Region, the Oregon State Director of BLM, and the Oregon State Department of Forestry for review and approval. The Regional Forester and State Director of the BLM subsequently agreed to accept the plan as a guideline for spotted owl management, pending the completion of their agencies' long-term management plans. Based on the land area within their jurisdictions, the Forest Service and BLM agreed to manage for 290 and 90 pairs, respectively. It was assumed that the remaining 20 pairs out of the 400 total would be managed on state forest lands and other ownerships.

In 1980, the composition of the Oregon Endangered Species Task Force changed. Representatives from Oregon State University were dropped from the Task Force and representatives from the Washington Department of Game were added. The name of the Task Force was changed to the "Oregon-Washington Interagency Wildlife Committee." At the same time, there were membership changes within the Spotted Owl Subcommittee, similar to the changes that occurred in the parent committee.

In 1980, the Spotted Owl Management Plan was modified to conform with new (and, at that time, unpublished) information concerning home range areas and habitat use of spotted owls in Oregon (Forsman and others, 1984; Forsman and Meslow, 1985). Because this information indicated that most pairs used large home ranges that encompassed at least 1,000 acres of old-growth forest, the Spotted Owl Subcommittee recommended that the minimum amount of old growth to be managed for each pair of owls should be increased to 1,000 acres (Oregon-Washington Interagency Wildlife Committee, 1981). The Committee further recommended that the old growth be located within a 1.5 mile radius of the nest area because the available

radiotelemetry data indicated that nesting pairs restricted most of their foraging to within a 1.5 mile radius of the nest (Forsman and others, 1984).

As pointed out in the discussion of habitat use, it is important to recognize that 1,008 acres of old growth was the minimum amount of old-growth forest observed within the home ranges of the six pairs that were studied in Oregon (Forsman and Meslow, 1985). Furthermore, three of the six pairs (including the pair that had only 1,008 acres of old growth within their home range) were only observed for four months during the spring and summer (Forsman, 1980; Forsman and others, 1984). Had these pairs been observed for a longer time, it is likely that estimates of their home range areas and the amount of old growth encompassed by their home ranges would have been even larger (Forsman and others, 1984).

The revised plan also included specific details on the recommended structure of the old-growth forests to be managed for spotted owls. Specific silvicultural techniques for managing forests within spotted owl management areas were not discussed, however.

As of 1985, neither the BLM nor the USDA Forest Service had formally accepted the 1981 revisions to the Spotted Owl Management Plan. However, the Regional Forester of the Pacific Northwest Region did agree to maintain the option to manage for 1,000 acres of old growth in Spotted Owl Management Areas if further studies indicated that the increased acreage was justified.

The final decision of the USDA Forest Service on spotted owl management was published in the Regional Guide for the Pacific Northwest Region (USDA Forest Service, 1984). The direction in the Guide was based on the Oregon Spotted Owl Management Plan as the guideline for management, except that the number of pairs selected for management in Oregon was 263 instead of 290. In 1985, a coalition of environmental groups (the National Wildlife Federation, the Oregon Wildlife Federation, the Lane County Audubon Society, and the Oregon Natural Resources Council) appealed the Regional Guide on the grounds that the spotted owl management plan was a major federal action that affected the environment and, therefore, required an environmental impact statement (National Wildlife Federation and others, 1984). One of the major criticisms raised by this group was that the spotted owl management plan was based on minimums rather than averages. In response to this appeal, the Forest Service agreed to develop a supplement to the Final Environmental Impact Statement for the Regional Guide for the Pacific Northwest Region. The supplement will address spotted owl habitat management.

Washington

Habitat management for pairs of owls on Forest Service lands in Washington is based on the guidelines in the Oregon Spotted Owl Management Plan. The USDA Forest Service tentatively decided to manage for 112 pairs of spotted owls in Washington (USDA Forest Service 1984:3-14). Few other pairs of owls will be provided for on non-Federal lands. The number of pairs in

wilderness and other reserved areas in Washington is poorly documented, but could be significant. The Washington Department of Game is currently conducting a survey of spotted owls in the Olympic National Park. This survey should provide a better estimate than is now available of the number of pairs within the Park. During the first year of this survey, a number of spotted owls were located in the Park, but the number of resident pairs was not determined (Sisco, 1985). In addition, the Washington Department of Game is considering a recommendation to increase to over 2,000 acres[18/] the amount of old growth to be managed for pairs of spotted owls.

California

Spotted owl management in California is based on the guidelines in the Oregon Spotted Owl Management Plan, with one major difference: the number of pairs selected for management was left up to the individual National Forests (Carrier, 1985). In northwestern California and the Sierra Nevada Mountains, approximately 500 to 550 pairs were selected for management through this process.[19/] Because relatively few pairs have been located in the Coastal Mountains of southern California, the National Forests in that area have chosen to protect and manage the habitat of all known pairs.[20/] Individual forests are in the process of developing management prescriptions for their respective management areas.[21/] Aside from those pairs that are protected on Forest Service lands, relatively few will be protected in California. Exceptions to the relative lack of protection are in national parks, national monuments, wildernesses, and other reserve areas. The BLM has limited landholdings within the range of the spotted owl in California and does not, at present, plan to develop any spotted owl management areas. However, the BLM does plan to manage a small number of old-growth reserves in northern California which should provide some habitat for spotted owls.[22/]

MONITORING

Implementation of a management plan for spotted owls requires that the managed sites be closely monitored to determine if the objective, a viable population of owls, is being met (Oregon Endangered Species Task Force,

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18/ Personal communication, L. Brewer, Washington Department of Game, Olympia, Washington.

19/ Personal communication, D. Carrier, USDA Forest Service, Pacific Southwest Region, San Francisco, California.

20/ Pacific Southwest Region, San Francisco, California, Ibid.

21/ For example, see silvicultural prescriptions proposed by Six Rivers National Forest under cover letter from Zane Smith (Regional Forester, Pacific Southwest Region); sent to Pacific Southwest Region Forest Supervisors and Staff Directors, 17 December 1982.

22/ Personal communication, W. Neitro, Bureau of Land Management, Portland, Oregon.

1977). Although a number of monitoring plans have been proposed (including Carey and Ruggiero, 1985; Lint, 1984), there has been little progress in implementing a coordinated, consistently funded monitoring plan that is acceptable to all of the agencies involved. As a result, monitoring efforts both within and among agencies, have varied in terms of effort, continuity, and objectives. Not surprisingly, the data collected from this potpourri of monitoring efforts are, in many cases, difficult to interpret or compare.

In an effort to derive minimum standards for the monitoring effort on USDA Forest Service lands, the Pacific Northwest Regional Office released a set of standards and guidelines in 1980 for verification of spotted owl management areas (USDA Forest Service, 1980). Under these standards, a site could be considered verified (i.e., occupied) if: (1) a pair of birds or their young had been observed or heard in the area within the previous three years; or (2) one or more adults had been heard or seen in the area on three separate occasions, spaced at least 72 hours apart, within the previous three years. These standards for verification were still being used in the Pacific Northwest Region as late as 1985.

During 1985, an interagency committee made up of representatives from the USDA Forest Service (the Pacific Northwest and Pacific Southwest Regions) and the Bureau of Land Management (Oregon and California), developed a series of monitoring plans for spotted owls (Old-growth/Forest Wildflife Habitat Development Action Plan Steering Committee, 1985). These recommendations are still under review by the Steering Committee.[23/]

In the absence of a coordinated plan to monitor spotted owl populations and management areas, numerous independent efforts at monitoring have been developed. Some of these are summarized below:

Washington

1. Tom Owens of the Washington Department of Natural Resources is compiling a data base containing all historical records of the spotted owl in Washington.

2. In 1984, The Washington Department of Game and the USDA Forest Service initiated a monitoring program of spotted owl management areas in Washington (Carey and Ruggiero, 1985; Allen and Brewer, 1985a, b). Objectives of this study are to: (1) determine occupancy rates of spotted owl management areas; (2) determine if adequate habitat is protected by the areas that are selected for management; and (3) determine if the verification standards for the spotted owl management areas that are being used by the Pacific Northwest Region are adequate (Carey and Ruggiero, 1985).

[23/] Personal communication, G. Starker, Bureau of Land Management, Portland, Oregon.

Oregon

1. The Oregon Department of Fish and Wildlife has recently developed a data base in which all historical observations of the spotted owl in Oregon are compiled. This data base is current through 1984 and is being revised to include 1985 data.

2. In 1984, the Roseburg District of the BLM initiated an intensive monitoring program for spotted owls within the District (Lint and others, 1984). The objective of this plan is to monitor at least 40 pairs of owls each year, including all 19 pairs that the District has selected for management. Sites occupied by each pair will be visited at least several times each year to determine nesting status, nest location, and reproductive success. All of the adults to be monitored will be color banded so that they can be individually identified. Although no deadlines have been set, this is expected to be a long-term study.[24/]

California

1. In 1985 the Pacific Southwest Regional Office of the USDA Forest Service implemented a ten-year monitoring program on a sample of 30 pairs of spotted owls that occupy management areas in northern California. There are ten pairs each on the Shasta-Trinity, Six Rivers, and Klamath National Forests. Each site will be visited every year to determine if a pair is present. An attempt will be made to correlate occupancy rates with the condition of the habitat. One of the main objectives of this study is to determine if the minimum management requirements that have been established for spotted owls on Forest Service lands are adequate.[25/]

2. Another monitoring effort in northern California is being funded by the California Department of Fish and Game and McIntyre-Stennis Funds. It is being conducted at Humboldt State University. Objectives of this study are to determine the total number of pairs within a large study area (roughl 110 square miles) and to collect information on factors such as population turnover, reproductive performance, and site fidelity.[26/]

3. Gordon Gould of the California Department of Fish and Game has compiled a data base of all historical records of the spotted owl in California. He plans to update this data base at regular intervals.[27/]

24/ Personal communication, J. Lint, Bureau of Land Management, Roseburg, Oregon.

25/ Personal communication, W. Laudenslayer, USDA Forest Service, Pacific Southwest Region, San Francisco, California.

26/ Personal communication, R. Gutierrez, Humboldt State University, Arcata, California.

27/ Personal communication, G. Gould, California Department of Fish and Game, Sacramento, California.

British Columbia

The British Columbia Ministry of Environment funded a survey of spotted owls in British Columbia that was conducted during the spring and summer of 1985. It is anticipated that additional surveys will be conducted in the future.[28/]

RESEARCH AND INFORMATION NEEDS

Needs for further research and information concerning the spotted owl have been summarized many times (Mannan and Meslow, 1979; Oregon Endangered Species Task Force, 1977; Carey, 1985; Gutierrez, 1985). Some topics recur in many of these reviews and are listed below, not necessarily in order of importance.

1. Population Monitoring: There is a need for a coordinated, long-term monitoring effort to determine if the spotted owl management plan is working. Ideally, this effort would involve a comparison of population trends, reproductive rates, and survivorship rates between managed and unmanaged areas. In addition to monitoring efforts directed at management areas, agency biologists should continue to expand the inventory of unmanaged areas, the idea being to get a better idea of the total distribution and size of the population of owls. Better inventory data on the general population will provide more options for selecting management sites or alternate management sites.

2. Demographics: There is a need for better information on the demographic characteristics of spotted owl populations, including reproductive rates, survivorship, age structure, longevity, population trends, and the average age at which individuals begin to breed. Among other things, this information could be used to estimate parameters of viable populations.

3. Additional studies of habitat used by adult spotted owls are needed in order that regional differences in habitat use and structure can be better identified and incorporated into management plans. These studies should be designed to provide quantitative information on the structure of habitats that are used for foraging, roosting, and nesting (e.g., see Solis (1983) and Sisco and Gutierrez (1984)). This will provide silviculturists with information that is needed for experimentation with techniques to create spotted owl habitat on cutover areas.

4. Studies of Prey Populations: It is suspected that prey populations may have a major influence on habitat selection and

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28/ Personal communication, Dave Dunbar, British Columbia Ministry of Environment, Vancouver, British Columbia.

reproductive behavior of spotted owls. Specific studies needed to examine these suspected relationships include: (1) a comparison of the abundance of the major prey in different forest types and age classes; and (2) overlapping studies of prey populations and rates of owl reproduction. The second study, in particular, could be coordinated with demographic studies. Sampling of prey could be conducted within areas occupied by the owl pairs that were being monitored.

5. Juvenile Dispersal and Survivorship: Studies of juvenile dispersal and survivorship need to be conducted over relatively long periods of time to insure that the data accurately reflect average long-term survivorship rates. This would be in contrast to using a small sample that may be biased by one or two years of atypical survivorship. It is unclear whether the data collected thus far accurately reflects juvenile survivorship rates.

6. In order to implement the spotted owl management plan, other critical information is needed. The nest areas and principal roost areas of <u>all</u> pairs selected for management need to be determined. This should be done before the final boundaries of the management areas are decided upon to insure that nest areas and principal roost areas are not accidentally excluded from management areas.

Table C-1

Summary of Information Relating to Reproductive Performance of Spotted Owls in Oregon, Washington, and California

Source	Years of Study	Number of Pairs Studied Each Year	Number or Owl-years[1/]	Percent of Pairs Fledging Young Each Year		Percent of Pairs Nesting Each Year	
				$\bar{X}$	range	$\bar{X}$	range
Forsman and others. (1984)	72-76	14-37	130	44	6-82	62	16-89
Barrows (1985)	77-84	n.p.[2/]	47	45	n.p.	n.p.	n.p.
Gutierrez and others. (1985)	82-84	14-45	92	19	0-33	36	0-45
Laymon & Barrett (1985)	82-84	16-19	49	10	5-21	1[3/]	5-21

1/ Each year that a pair was observed was considered an "owl-year." If 15 pairs were observed in a given year, this amounted to 15 owl-years of data.

2/ Data not presented.

3/ Laymon and Barrett (1985) did not check pairs for nesting until July or August. It is not clear, therefore, how they knew if the birds attempted to nest or not.

Table C-2

Summary of Results of Spotted Owl Dispersal Studies[1/]

Authors	Number of Owlets Marked	No. Dead or Fate Unknown Before Dispersal was Initiated	No. Initiating Dispersal but Dead Before Dispersal Completed	No. Initiating Dispersal but Fate Unknown
Forsman and others. (1984)	4	2	2	
Allen & Brewer (1985)	6		4	2
Laymon & Barrett (1985)	12	8	2	2
Gutierrez and others. (1985b)	38	15	12	11

1/ Data from a study by Miller and Meslow (1985) were not available for review.

Table C-3

Composition of the Diet of Spotted Owls in Different Regions
Data indicate percent of prey numbers.

Region	British Columbia	Oregon			California				
		Coast Range	W. Slope Cascade Range	Southwest Oregon	Northwest Coast		Sierra Nevada Mts.		Pennin-sular Range
Source1/	1	2	2	2	3	4	5	6	3
Sample Size	16	1,214	817	651	375	240	33	523	296
Flying Squirrel	31.2	35.2	42.4	17.7	14.9	7.1	29.7	23.6	
Woodrats		4.9	2.2	39.0	29.9	45.0		7.7	33.1
Red tree vole		19.1	13.3	4.9	17.1	12.5			
Red backed vole		5.5	9.2	9.5		4.0			
Rabbit or hare		4.3	2.5	2.6	0.3	0.4			0.3
Deer mouse	31.2	11.7	8.7	5.0	12.8	6.2	9.1	19.4	30.7
Other mammals	31.2	8.2	15.1	13.2	3.2	16.3	24.3	16.2	9.4
Birds	6.2	3.0	3.1	6.4	10.3	1.7	18.2	15.9	9.2
Insects/ Arthropods		7.8	3.4	1.7	12.0	6.8	15.1	17.2	17.6
Other		0.3	0.1						
Totals	98.8	100.0	100.0	100.0	100.5	100.0	99.9	100.1	100.3

1/ Sources of data were: 1 = Smith (1963); 2 = Forsman and others (1984); 3 = Barrows (1980); 4 = Solis (1983); 5 = Marshall (1942); 6 = Laymon and Barrett (1982).

Appendix D

MONITORING AND RESEARCH

INTRODUCTION

A review of the literature (Appendix C) and modeling of owl viability given current information (Chapter 4 and Appendix B) has highlighted the need for additional information on northern spotted owl biology and habitat requirements. The preferred alternative, F, provides for management of owl habitat over the next ten year period in a way that will maintain options for future management decisions. Monitoring and research will provide a sounder basis for future refinement of management direction for the owl.

The role of monitoring with respect to the Supplement is different than the role of research. Monitoring is used to determine if the selected alternative is implemented in accordance with its standards and guidelines. Monitoring is also used to determine if projected outcomes do occur and to test assumptions used in making management decisions. Research provides the information necessary to more fully understand the biology of the northern spotted owl and is also used to test the assumptions used in the analysis.

MONITORING

The purpose of this monitoring section is to identify that information which will be used to track the outcome of the management decision for northern spotted owl habitat. Specifically, the decision relates to the size and distribution of habitat areas needed to ensure northern spotted owl viability, and whether the selected alternative meets, exceeds or does not provide the habitat required to protect the spotted owl. Should changes be needed to ensure the continued survivial of the spotted owl, monitoring will disclose possible problem areas. The evaluation period as defined by this monitoring plan is the ten to fifteen-year period immediately following the adoption of the standards and guidelines as part of forest plans, pursuant to the Regional Guide. It is during this time that the standards and guidelines will be implemented.

Critical objectives of the monitoring program are:

-To improve the inventory of spotted owl habitat on Forest Service, Bureau of Land Management, and National Park Service lands. The information specifically needed is the amount, condition and location of remaining mature and old-growth forests.

-To evaluate the change in spotted owl habitat over time.

-To obtain an accurate estimate of the owl population within Forest Service reserved areas and on lands administered by the National Park Service.

-To track trends in occupancy of designated owl habitat areas.

-To track trends in reproductive success of spotted owls in designated habitat areas.

-To evaluate the impacts of land management practices, such as timber harvesting, on occupancy of identified habitat areas.

The Old-Growth Wildlife Research and Development Program Steering Committee, through a subcommittee on monitoring, developed a draft task force report on monitoring of spotted owls and old-growth (1985) which recommended that the Forest Service and the BLM evaluate the occupancy and reoccupancy of sites, reproductive success, techniques and assumptions for modeling viability, effects of silvicultural prescriptions on habitat areas, and integrity of old-growth stands over time. Some of these items are discussed in the research section of this Appendix rather than in monitoring because they are related to understanding the biology of northern spotted owls and not to implementation of the selected alternative.

Owl Habitat Inventory

In managing spotted owl habitat, the underlying goal is to assure a viable population of owls. Furthermore, evaluation of the alternatives presented in this Supplement required information on amounts and distribution of suitable habitat available both now and in the future. An improved inventory of existing habitat and estimates of historic distributions of habitat is needed to serve as a baseline for tracking future changes in habitat.

The inventory should determine both the amount and location of suitable spotted owl habitat. The inventory will be designed so that individual stand characteristics (i.e., diameter, canopy closure, stem density) are measured and recorded rather than being lumped within categories such as mature and old-growth. This will provide the flexibility to identify acres which meet specific criteria as definitions of suitable spotted owl habitat are refined.

Approximately 95 percent of the habitat suitable for spotted owls is located on lands managed by the Forest Service, the Bureau of Land Management, and the Park Service (see Table 3-5). Inventories of mature and old growth habitat will be necessary on the lands administered by all these agencies. Inventories for a single purpose are often expensive, so coordination among agencies, as well as integration of inventories for owl habitat with other resource inventories, is suggested. The figures presented in Table D-2 are based only on inventories on National Forests.

Change in Spotted Owl Habitat Over Time

Monitoring of change in habitat over time will provide estimates of the reduction in the amount of habitat due to timber harvest; the development of additional acres of suitable habitat through succession; and the loss of habitat due to fire, windthrow, insects, disease and other natural processes.

Reduction in habitat due to timber harvest will be tracked through the timber sale planning process, periodic re-inventory of forested lands, and additional mapping efforts from remote sensing. The development of additional suitable acres through succession will also be tracked through standard inventory procedures and mapping based on remote sensing.

The potential loss of habitat due to natural processes could have a significant effect on efforts to provide for a viable population of spotted owls. Increasing fragmentation of mature and old-growth habitat may make remaining patches more vulnerable to catastrophic loss. Such losses will be tracked through inventory and mapping from remote-sensing imagery. A sample of habitat patches will be observed more frequently to determine how the frequency and intensity of habitat loss due to natural processes is related to habitat patch size and fragmentation and the nature of the surrounding landscape.

Estimates of Numbers of Spotted Owls on Reserved Lands

The area of reserved lands (lands unavailable for timber harvest) on National Forests that are suitable for spotted owls has never been accurately determined in the field. The viability analysis assumed that these lands would provide habitat capable of supporting 211 owl pairs in all the alternatives that were considered. (Refer to Appendix B for a discussion of how this capability estimate was derived for reserved lands.) A similar estimate was derived for habitat capability of National Parks based on available inventory or suitable habitat in several parks. (This estimate is also discussed in Appendix B.)

The monitoring program will include an intensive effort to validate the estimate of capability to support owls within reserved lands on National Forests. This effort will extend habitat inventories to these lands and will entail sampling efforts aimed at determining the density of owl pairs in representative portions of the reserved lands. This effort should be coordinated with parallel efforts on National Parks.

Occupancy Estimates of Suitable Habitat Over Time

Inventories of suitable owl habitat indicate that not all available areas are actually occupied by owls. Allen and Brewer (1985) found that about 52 percent of the designated spotted owl management areas they surveyed in Washington were actually occupied by owls. Solis and Gutierrez (1984) suggest a 60 percent occupancy rate for suitable habitats in northern California.

Occupancy of suitable habitat is related to the size, quality, and fragmentation of individual habitat areas and to the distribution of areas across the landscape. The preferred alternative places an emphasis on the designation of areas where occupancy has been verified, but the overall occupancy of designated areas may change as habitat becomes more fragmented in the future. A decrease in occupancy over time would substantially increase the risk of extinction of the spotted owl population.

Monitoring in the first decade will evaluate the occupancy of designated habitat areas and, consequently, the effectiveness of the implementation guidelines. The intensity of the monitoring effort will vary among the physiographic provinces within the Region. A greater level of precision in monitoring will be necessary in the Olympic Peninsula than in the Oregon Cascades. This is because the Olympic Peninsula has a population of owls that may be isolated and the risk of extinction may be higher on the peninsula than in the more southern provinces. The greater precision will be obtained through a more intensive level of sampling.

Estimates of occupancy in habitat areas on lands managed by the National Park Service and Bureau of Land Management should also be evaluated for changes over time. Surveys of spotted owls in National Parks may provide information on occupancy of habitat that has undergone change due only to natural processes.

Determination of Reproductive Status of Spotted Owls

It is important to monitor both the occupancy of designated habitat areas and the reproductive success of the spotted owls occupying those habitat areas. Samples of nesting attempts, eggs, nestlings, and fledglings will provide information on trends in reproduction rate over time.

Impacts of Land Management On Use of Management Areas

Land management practices conducted over the last 30 years have increased the degree to which forest tracts are fragmented. The effects of fragmenting forest stands on habitat use, rates of dispersal by juvenile owls, juvenile mortality, and size of home range need more study. Designated spotted owl habitat areas may consist of contiguous stands of mature and old-growth or patches of old-growth intermingled with young-growth stands. The effects on occupancy by owls of harvesting within and adjacent to designated owl habitat areas needs to be investigated.

Interagency Cooperation

Management of spotted owl populations is generally the responsibility of the state wildlife agencies, and the Federal agencies are responsible for management of the habitat on their land. Therefore, monitoring will also need to be done on lands managed by Federal agencies other than the Forest Service. In order to best address this need, it is recommended that monitoring for estimates of population, rates of occupancy, reproductive

status, and effects of management on owl behavior be conducted by state agencies through interagency agreements with the Forest Service, Bureau of Land Management, and National Park Service. This cooperative approach will provide uniformity in the process so results can be coordinated within a state's jurisdiction.

Such an effort is currently underway on National Forests in Washington. Biologists from the Washington Department of Game are working under a supervisory committee of biologists from three National Forests, the Forest Service Pacific Northwest Experiment Station, and the Washington Department of Game. This arrangement provides for supervision by experienced avian biologists, use of trained personnel, random sampling of study areas, a firm schedule for reporting, and assistance provided by managers in identifying, locating, and gaining access to study areas.

Monitoring Intensity, Costs and Duration

The sampling intensity and the projected cost of monitoring varies by alternative. Sampling of occupancy of designated habitat areas needed to attain a given level of precision is shown in Table D-1. Table D-2 summarizes the sampling costs by alternative and monitoring requirements over the next ten year period.

All monitoring costs remain constant across the alternatives except for those associated with monitoring of habitat areas for occupancy and reproductive status. This is because the improved inventory, estimates of spotted owls in reserved areas, and estimates of change through time need to be obtained under any alternative. This information is necessary to provide a better basis for management decisions ten years hence.

Monitoring of habitat areas for occupancy and reproductive status of spotted owls varies by alternative. The monitoring efforts and costs are considerably higher for Alternatives A, B, and C which provide less habitat and a different distribution of habitat areas than other alternatives. Sampling of occupancy and reproductive status are also more intense under alternative F because that alternative calls for accelerated monitoring and research efforts to more precisely determine habitat use by spotted owls.

The monitoring will be done for five years, after which the results will be used to determine the additional needs for monitoring and intervals for sampling during the rest of the planning period. Information collected during the ten-year planning period on the biology of the spotted owl will be used, both during and at the end of the period, to reevaluate the objectives underlying the monitoring plan, and to develop and refine standards for future management of the species.

Review Process

On each of the 13 National Forests which support northern spotted owls, the implementation of this monitoring plan will be reviewed at least once every two years by the Regional manager for the threatened and endangered species

program. Accomplishments in monitoring will be documented in periodic reports to all involved agencies as well as to the Oregon-Washington Interagency Spotted Owl Subcommittee.

RESEARCH

Purpose and Scope

The purpose of this research is to refine the scientific basis for management and maintenance of northern spotted owl populations and their habitat and to test assumptions used in analyzing viability of the spotted owl. This section identifies the type of information and kind of research deemed necessary within the next ten to 15 years to more fully understand the biology of northern spotted owls and provide a basis for refining decisions regarding management of spotted owl habitat.

A number of spotted owl research information needs have been identified in the Symposium on the Ecology and Management of Spotted Owls in the Pacific Northwest (Gutierrez and Carey, 1985). Other needs have become apparent during the preparation of this Supplement, particularly during the viability analysis of the proposed management alternatives. The highest priority areas for spotted owl research are shown below. Relative priorities are given for the individual research items in Table D-3.

-Habitat requirements of breeding pairs of spotted owls
    --Habitat used by pairs
    --Habitat improvement through management

-Population dynamics including:
    --Demographics
    --Dispersal and recruitment
    __Population structure and trends

-Ecological relationships including:
    --Predation on spotted owls
    --Competition with barred owls
    --Interactions with prey species and habitat requirements of those species

-Laboratory studies and analytical tools:
    --Experimental studies
    --Viable population theory and model development
    --Propagation of owls and augmentation of populations

Research Activities

Habitat Requirements of Breeding Pairs of Spotted Owls

Habitat (foraging, thermal cover, nest sites) is important to the distribution of any wildlife species. The old-growth forests which appear to provide preferred habitat for the spotted owl exist today largely as fragments or islands.

A critical need is to distinguish the relative role of habitat quality (in terms of thermal cover, nest sites, roost sites, and prey base), quantity (in terms of size and number of mature and old-growth stands), and the distribution of such elements as they affect breeding pairs of spotted owls (Gould, 1979; Barrows and Barrows, 1978; Forsman, 1978). Studies will be replicated geographically and over time. Within regional and landscape contexts, studies of habitat capability should address:

1. The factors that influence the selection of nesting habitat, home range, and related habitat needs throughout the range of the northern spotted owl.

2. The influence of amount and distribution of suitable habitat within the home range of spotted owl pairs on reproductive success.

3. The feasibility of providing spotted owl habitat by silvicultural treatments (Solis, 1982; Sisco and Gutierrez, 1984) or direct habitat improvements (e.g., nest structures for spotted owls and northern flying squirrels).

4. Differences in habitat used by breeding owl pairs between east and west-side Cascade locations.

5. The possibility of a north-south gradient in spotted owl habitat requirements.

Population Dynamics

Demography

A major need in any approach to determining population viability is an in-depth understanding of population dynamics (Salwasser and others, 1983; Samson and others, 1985). Information collected here will be used to determine average values and variability of reproduction rate, fledging rate, pre-dispersal mortality, dispersal mortality, subadult and adult mortality, and the ability of spotted owls to colonize vacant but suitable habitat.

Dispersal and Recruitment

Analysis of dispersal characteristics and habitat use by juvenile, subadult, and unpaired adult birds is important to understanding population dynamics and habitat requirements of the species. The survival rate of dispersing juvenile spotted owls may be less than that expected among other large bodied, long lived bird species. Little is known about numbers, distribution, or movement of subadult or unpaired adult birds that may be a source of replacement when adult paired birds die or otherwise vacate habitat. Further, little information is available that describes the specific habitats used during dispersal and the time interval between dispersal and the occupancy of a breeding territory. This research should emphasize:

1. Distances traveled, survival of, and patterns of habitat use by juvenile and subadult spotted owls (Solis, 1982; Gutierrez, 1985; Forsman, 1985).

2. Habitat use and movement of subadult and unpaired adult owls as related to presence and distribution of adult breeding owls (Gutierrez, 1985; Forsman and others, 1985).

Another important question relating to dispersal and recruitment is the possibility that large bodies of water and extensive open areas serve as barriers or impediments to dispersal. If feasible, dispersal and recruitment studies will be used to determine if the following landforms serve as barriers or impediments to spotted owl movements:

1. The land and water surrounding the Olympic Peninsula may act to isolate the Olympic Peninsula owl population from the Washington Cascade population.

2. The population in the Oregon Coast Range may be isolated by the reduction in recent decades of suitable habitat that previously joined it to the population in the Oregon Cascades and Klamath Province.

3. The Columbia River Gorge may serve as a barrier or an impediment between the Washington and Oregon Cascades.

Population Structure

The structure of a population is the relative frequencies of sexes, age classes, and animals of breeding and non-breeding status. This information is important for modeling population changes and population viability.

Ecological Relationships

Predation on Spotted Owls and Competition with Barred Owls

Studies of predation on, and competition with, spotted owls can provide information about long-term results of major alterations of the character of the landscape through forest management. The great horned owl (Bubo virginianus) and northern goshawk (Accipiter gentilis) are known to kill spotted owls (Forsman, 1977; Solis, 1984). The barred owl (Strix varia) is invading the spotted owl's range in the Olympic Pennisula and Cascade Mountains of Washington and Oregon, and has been observed adjacent to or within suitable spotted owl habitat (Garcia, 1979; Allen and others, 1985; Hamer and Allen, 1985). Great horned owls, northern goshawks, and barred owls generally inhabit landscapes that consist of fragmented habitat with much edge and a diversity of cover types (Verner and Boss, 1980; Brown, 1985; Nicholls and Warner, 1972). Thus an important information need is to further our understanding of how fragmentation of habitat, as would occur through some forest management activities, would enhance the distribution and abundance of these three species, facilitate increased predation on

spotted owls by great horned owls or northern goshawks, or increase competitive exclusion of spotted owls by barred owls. Competition for habitat is of particular importance in Washington where nearly 20 percent of the spotted owl management areas studied by Brewer and Allen (1985) now are occupied by barred owls.

Prey Relationships of Northern Spotted Owls

Studies of prey relationships can result in useful management information. In addition to explaining why spotted owls use such large areas, results might suggest how silvicultural prescriptions or direct habitat improvements might be used to compensate for lack of suitable habitat. Such studies may suggest that the total area of suitable habitat required by a family of spotted owls may vary with the types and densities of prey. If this is determined to be true, then sizes of spotted owl habitat areas may be varied, by geographic location, according to the prey base requirements.

Laboratory Studies and Analytical Tools

The framework used to analyze viability of spotted owl populations requires additional refinement. This will be the purpose of collaborative efforts between scientists and managers. In addition, some of the research techniques used for spotted owls require further refinement and study. For example, the research proposed here includes a study of the effects of radio-telemetry instrumentation on foraging and physical activity of owls.

Experimental studies under controlled laboratory conditions could be valuable in interpreting and validating the results of predation and competition studies. Experimental studies will include controlled studies of responses to environmental structure and competitive behavior.

In addition, there is a need to study the possibility of augmenting spotted owl populations using owls propagated in captivity. See Chapter 4 for a discussion of some of the specific information requirements for augmentation of populations.

Costs and Duration of Research

Table D-3 provides a summary of the annual costs of research, by alternative and identified need, over the next ten-year period. Except for that research related to habitat quantity and quality for breeding owl pairs, all costs to conduct research remain the same across the alternatives.

Costs among alternatives do not vary greatly because additional scientific information will be needed to refine future management direction regardless of the alternative that is chosen. Research conducted within the next ten-year planning period should provide information to more clearly support the management decisions to be made ten years hence. Therefore,

irrespective of the management alternative chosen today, nearly the same amount of research will be needed to provide that information. Costs for research on habitat improvement through management, captive propagation, and augmentation of populations would be greater in those alternatives providing 1000 acres or less of suitable habitat per area.

Table D-1

Precision Level and Sample Size for Monitoring Spotted Owl Management Areas for Occupancy

Figures assume a true occupancy rate of habitat areas by spotted owls of 60 percent. Sample sizes would be larger if the true occupancy rate was closer to 50 percent, and lower if the true occupancy rate was greater than 60 percent. Each sample is a habitat area that would be monitored for occupancy.

Precision	Number of Samples Required [1/]
± 0%	811
±10%	550
±15%	225
±20%	125

[1/] This is based on attaining the stated level of precision for each of 4 spotted owl populations (Olympic Peninsula, Washington Cascades, Oregon Cascades plus Klamath Mountains, and Oregon Coast Range). This assumes that the Columbia River Gorge is a barrier to dispersing spotted owls, so that populations on either side would have to be sampled separately.

Table D-2

Projected Cost (in $1,000) of Spotted Owl Monitoring by Need and Alternative

		Alternative											
		A	B	C	D	E	F	G	H	I	J	K	L
No. Habitats:		No	Reser.	417	550	810	550	550	620	784	1000	1000	No
Size(acres):		Meas.	Only	300	1000	1000	2200	2200	2200-OR 4200-WA	6600	2200	2900	Reduct.
Monitoring Need	Duration	Annual Cost											
Owl Habitat Invenrory[1/]	5 years	160	160	160	160	160	160	160	160	160	160	160	160
Change in Spotted Owl Habitat Over Time[2/]	Continuing	68	68	68	68	68	68	68	68	68	68	68	68
Estimates of Numbers of Spotted Owls on Reserved Lands[3/]	5 years	60	60	60	60	60	60	60	60	60	60	60	60
Habitat Area Monitoring by Physio. Province[4/]	Precision:	±10%	±10%	±10%	±15%	±15%	±10%	±15%	±15%	±20%	±20%	±20%	±20%
a. Occupancy Estimate of Suitable Habitat Over Time	Continuing	150	121	134	82	88	142	82	82	60	60	60	60
b. Determination of Reproductive Status of Spotted Owls	Continuing	75	53	63	65	70	69	65	65	24	24	24	24
Impacts of Land Mgt. on Use of Habitat Areas[5/]	Continuing	50	50	50	50	50	50	50	30	50	50	No Sample	No Sample
First yr. cost		563	512	535	485	496	549	485	465	422	422	372	372
Fifth yr. cost		563	512	535	485	496	549	485	465	422	422	372	372
Tenth yr. cost		343	292	315	265	276	329	265	245	202	202	152	152

1/ Estimated cost from inventories conducted in Pacific Southwest Region, USDA Forest Service.

2/ Includes collection of data once each 5 years using remote sensing ($12,000) and analysis ($78,000) per cycle. Two cycles sampled per decade, average annual cost is $18,000. Data taken from Old-growth/Wildlife Habitat Coordination Committee Task Force Rpt (BLM 5240/1700(932) of 7/24/85). Additional $50,000 is for administrative studies on effects of habitat fragmentation on habitat persistance and condition.

3/ Population estimation will require 5 years to inventory.

4/ Sampling precision follows Table D-1 where intensity varies with alternative. Reproductive status sampling is an incremental cost above occupancy estimation using 100 areas at $400 each.

5/ Radio telemetry of spotted owls. Estimate 10 areas at $5,000/area annually for 10 years.

Table D-3

Projected Cost (in $1,000) of Spotted Owl Research by Need and Alternative

		Alternative											
		A	B	C	D	E	F	G	H	I	J	K	L
No. Habitats:		No	Reser.	417	550	810	550	550	620	784	1000	1000	No
Size(acres):		Meas.	Only	300	1000	1000	2200	2200	2200-OR 4200-WA	6600	2200	2900	Reduct.
Research Need	Priority	Annual Cost											
Habitat Requirements of Breeding Pairs													
--Habitat Used by Pairs 1/	1	300	300	300	300	300	300	300	300	300	300	300	300
--Habitat Improvement	2	150	150	150	150	150	150	50	50	50	50	50	50
Population Dynamics 1/													
--Demographics	1	350	350	350	350	350	350	350	350	350	350	350	350
--Dispersal & Recruitment	1	250	250	250	250	250	250	250	250	250	250	250	250
--Population Structure and Trends 2/	2	250	250	250	250	250	250	250	250	250	250	250	250
Ecological Relationships													
--Predation on Spotted Owls	2	100	100	100	100	100	100	100	100	100	100	100	100
--Competition with Barred Owls	1	150	150	150	150	150	150	150	150	150	150	150	150
--Prey Ecology 1/	1	360	360	360	360	360	360	360	360	360	360	360	360
Laboratory Studies and Analytical Tools													
--Experimental Studies	3	100	100	100	100	100	100	100	100	100	100	100	100
--Propagation and Augmentation	*	500	500	500	500	500	500	200	200	200	200	200	200
--Viable Population Theory 3/	3	50	50	50	50	50	50	50	50	50	50	50	50
First yr. cost		2560	2560	2560	2560	2560	2560	2160	2160	2160	2160	2160	2160
Fifth yr. cost		2560	2560	2560	2560	2560	2560	2160	2160	2160	2160	2160	2160
Tenth yr. cost		1960	1960	1960	1960	1960	1960	1660	1660	1660	1660	1660	1660

1/ Studies under these topics will be geographically replicated
2/ Research contribution to cooperative monitoring/research effort
3/ Research contribution to cooperative development effort
* Priority varies with alternative. Priority is 1 under Alternatives A through E; 2 under Alternatives F and G; and 3 under Alternatives H through J.

Appendix E

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Appendix F

GLOSSARY

This chapter replaces the glossary, Appendix A, of the Regional Guide for the Pacific Northwest Region. The terms used in this supplement to the Regional Guide have been incorporated into the Regional Guide's glossary; therefore, the terms and definitions which follow include those which appear in either the original Regional Guide or the supplement or both.

Sources of Definitions

-A Dictionary of Statistical Terms, Third Edition, M. G. Kendall and W. R. Buckland (DST)

-Code of Federal Regulations, 36 CFR and 40 CFR (CFR)

-Ecology Field Glossary - A Naturalists Vocabulary, Walter H. Lewis (EFG).

-Eric Forsman, Consulting Wildlife Biologist, Corvallis Oregon (EF)

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-Glossary of Engineering Terms, Pacific Northwest Forest and Range Experiment Station, USDA Forest Service, 1979 (GET)

-Glossary from the Regional Guide for the Pacific Northwest Region, May 1984 (RG)

-Management of Wildlife and Fish Habitats in Forests of Western Oregon and Washington, USDA Forest Service, Pacific Northwest Region, 1985 (MWFH)

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-Society of American Foresters Dictionary of Forestry Terms (SAF)

-Webster's New Collegiate Dictionary (WEB)

-Wildland Planning Glossary, Pacific Southwest Forest and Range

Experiment Station, USDA Forest Service, General Technical Report PSW 13/1976 (WPG)

Glossary Terms

A

Acre Equivalent. RG. Used to adjust actual acres of habitat improvement or improvement structures to reflect overall habitat benefits derived. It reflects the zone of influence of the habitat improvement for the target species. For example, a single water development for upland game birds has an acre equivalent of 160, whereas a single water structure for big game has a value of 640 because it has a larger zone of influence for the more mobile big-game animals.

Activity. RG. Actions, measures, or treatments that are undertaken that directly or indirectly produce, enhance, or maintain forest and rangeland outputs or achieve administrative or environmental quality objectives. Forest Service activity definitions, codes, and units of measure are contained in the Management Information Handbook (FSM 1309.11).

Airshed. RG. A geographical area that, because of topography, meteorology, and climate, shares the same air.

Allowable Cut. WPG. The volume of timber which can be cut under specific management plans during a given period.

Allowable Sale Quantity. FSM. The quantity of timber that may be sold from the area of land covered by the Forest plan for a time period specified by the plan. This quantity is usually expressed on an annual basis as the average annual allowable sale quantity. (The allowable sale quantity applies only to the lands determined to be suitable for timber production, and to the utilization standards specified in the land and resource management plan.)

Alternative. RG. One of several policies, plans, or projects proposed for decision making.

Ambient. WPG. 1. Refering to surrounding, external, or unconfined conditions. 2. Refering to the quality of some specific environmental factor such as the "ambient" temperature or "ambient" air pollution levels.

Ambient Temperature. EFG. The encompassing temperature.

Amenity. RG. An object, feature, quality, or experience that gives pleasure or is pleasing to the mind or senses. Amenity value is typically used in land-use planning to describe those resource properties for which market values (or proxy values) are not or cannot be established.

Anadromous Fish. RG. Those species of fish that mature in the sea and migrate into streams to spawn. Salmon, steelhead, and shad are examples.

Animal Unit. RG. Considered to be one mature (1,000 lbs.) cow or the equivalent based upon an average daily forage consumption of 26 lbs. dry matter per day.

Animal Unit Month (AUM). RG. The amount of forage required by an animal unit for one month.

Appellant. CFR. A party or parties who appeals a decision of a Forest Service Officer according to the procedures as set out in 36 CFR 211.18.

Aspect. GET. The direction a slope faces with respect to the cardinal compass points.

Assessment. RG. The Forest and Rangeland Renewable resource Assessment required by RPA.

Average. See **mean**.

Avoidance Area. RG. An area having one or more physical, environmental, institutional, or statutory impediments to utility corridor designation.

B

Background. RG. The visible terrain beyond the foreground and middleground where individual trees are not visible, but are blended into the total fabric of the stand. See **Foreground** and **Middleground**.

Basal Area. SAF. The area of the cross-section of a tree stem near its base, usually at breast height and inclusive of bark.

Base Timber Sale Schedule. FSM. The timber harvest schedule in which the planned sale and harvest for any future decade is equal to or greater than the planned sale and harvest for the preceding dedade of the planning period. This planned sale and harvest for any decade will not be greater than long-term sustained yield capacity.

Bedload. Material on or near the bed of a stream and frequently in contact with it.

Big Game. RG. Those species of large mammals normally managed for sport hunting.

Biological Growth Potential. RG. The average net growth attainable in a fully stocked natural forest stand.

Biological Unit Management. WPL. Forest Service Usage. Any unit for management of a particuliar species or any unit of intensive or special management. The term includes any big-game management unit as recognized by a cooperating state, even though it may not be a strictly herd unit. In the case of fisheries management, the term may include a drainage system.

Biomass. RG. The total quantity (at a given time) of living organisms of one or more species per unit of space (species biomass), or of all the species in a biotic community (community biomass).

Board Foot. WPG. Lumber or timber measurement term. The amount of wood contained in an unfinished board one inch thick, twelve inches long, and twelve inches wide.

Broadcast Burn. RG. Allowing a prescribed fire to burn over a designated area within well-defined boundaries for reduction of fuel hazard or as a silvicultural treatment, or both.

Breast Height. GET. A standard height from average ground level for recording diameter, girth, or basal area, generally 4.5 feet (1.37 meters).

Brush. RG. A growth of shrubs or small trees usually of a type undesirable to livestock or timber management.

C

CEQ. RG. Council on Environmental Quality.

CFL. RG. Commercial Forest Land. See **Timber Classification**.

Canopy Closure. SAF. In a crop or stand of trees, the progressive reduction of space between crowns as they spread laterally, thereby increasing their density.

Capability. RG. The potential of an area of land to produce resources, supply goods and services, and allow resource uses under an assumed set of management practices and at a given level of management intensity. Capability depends upon current conditions and site conditions such as climate, slope, landform, soils, and geology, as well as on the application of management practices, such as silviculture or protection from fire, insects, and disease.

Capable Habitat. A forest vegetation type used by spotted owls as habitat, but which is presently in an unuseable seral stage, that is, younger than mature.

Cavity. RG. The hollow excavated in trees by birds or other natural phenomena; used for roosting and reproduction by many birds and mammals.

Chargeable Timber Volume. RG. The timber removed from regulated forest land that contributes to meeting the annual sustained-yield capacity.

Clearcut. SAF. An area where the entire stand of trees has been removed in one cutting.

Clearcutting. RG. The harvesting in one cut of all trees on an area for the purpose of creating a new, even-aged stand. The area harvested may be a patch, strip, or stand large enough to be mapped or recorded as a separate class in planning for sustained yield.

Climax. RG. The culminating stage in plant succession for a given site where the vegetation has reached a highly stable condition.

Climax Species. RG. Those species that dominate the stand in either numbers per unit area or biomass at climax.

Closed Sapling Pole. MWFH. Saplings and poles stands which are characterized by a closed tree canopy and very little ground cover. Tree crown closure will exceed 60 percent and often reaches 100 percent.

Clutch. EFG. The number of eggs laid by a female bird at one time.

Coastal Douglas-Fir Zone. RG. The area west of the crest of the Cascade Mountain Range in the States of Oregon and Washington.

Colonization. EFG. The establishment of an immigrant species across a peripherally unsuitable ecological area; except for occasional gene exchange with the parental population, the disjunct colcony evolves in virtual isolation and eventually may form a distinct entity.

Commercial Forest Land (CFL). See **Timber Classification.**

Commodity. RG. A transportable resource product with commercial value; all resource products that are articles of commerce.

Concern. RG. A point, matter, or question raised by management that must be addressed in the planning process.

Confidence Level. DST. The measure of probability associated with a **Confidence Interval** espressing the probability that the interval will include the parameter value.

Confidence Interval. A group of values used to estimated a statistical parameter (as an average) and that tends to include the true value of the parameter a predetermined proportion of the time, provided the sampling process is repeated a number of times.

Congressionally Classified and Designated Areas. RG. Areas that require congressional enactment for their establishment, such as national wildernesses, national wild and scenic rivers, and national recreation areas.

Conifer. SAF. A tree belonging to the most important order of the Gymnospermae, comprising a wide range of trees that are mostly evergreens. Conifers bear cones (hence coniferous) and needle-shaped or scale-like leaves and produce timber known commercially as softwood.

Consumptive Use. RG. Those uses of a resource that reduce its supply.

Contiguous. Habitat that is arranged to allow the edges or boundries to touch.

Corridor. RG. A linear strip of land identified for the present or future location of transportation or utility rights-of-way within its boundaries.

Corridor. A length of habitat along which wildlife can travel from one habitat area to another.

Cost Efficiency. RG. The usefulness of specified inputs (costs) to produce specified outputs (benefits). In measuring cost efficiency, some outputs, including environmental, economic, or social impacts, are not assigned monetary values, but are achieved at specified levels in the least cost manner. Cost efficiency is usually measured using present net value, although use of benefit-cost ratios and rates-of-return may be appropriate.

Created Opening. RG. Created openings are openings in the Forest created by the silvicultural practices of shelterwood regeneration cutting at the final harvest, clearcutting, seed tree cutting, or group selection cutting.

Critical Window. RG. A control point or area (such as a mountain pass) not to be designated within an existing utility corridor, but needed to retain future new utility corridor options.

Crown. SAF. The upper part of a tree or other woody plant which carries the main system of branches and the foliage and surmounts, at the base of the crown, a more or less clean stem.

Crown Closure. See **canopy closure.**

Cultural Resources. RG. The remains of sites, structures, or objects used by humans in the past--historical or archaeological.

D

D.B.H. RG. Diameter at breast height. The diameter of a tree measured 4 feet 6 inches from the ground.

D.I.B. RG. Diameter inside bark.

Decision Criteria. RG. Essentially the rules or standards used to evaluate alternatives. They are measurements or indicators that are designed to assist a decisionmaker in identifying a preferred choice from an array of possible alternatives.

Decision Space. DST. The set of all possible decisions.

Dedicated. Refers to any National Forest land that is designated for a use other than timber management and on which no timber harvest is scheduled.

Demography. EFG. The quantitative analysis of population structure and trends; population dynamics.

Density Biological Population. RG. The number or size of a population in relation to some unit of space. It is usually expressed as the number of individuals, or the population biomass per unit area or volume.

Departure. FSM. A deviation from the **base sale schedule.**

Designated Area (Air Quality). RG. Those areas delineated in the Oregon and Washington smoke management plans as principal population centers of air-quality concern.

Designated Habitat Area. An owl habitat area that has been located on a map or in the field or both.

Desirable Residual Vegetation. RG. The remaining vegetation after application of harvest cutting methods that meets management area objectives. The vegetation may be trees, shrubs, grass, or a combination.

Developed Recreation. RG. Recreation that requires facilities that, in turn, result in concentrated use of an area. Examples of recreation areas are compgrounds and ski areas; facilities in these areas might include roads, parking lots, picnic tables, toilets, drinking water, ski lifts, and buildings.

Disjunct. EFG. A geographicaly isolated population or species beyond the range of other similiar populations or species.

Dispersal. SAF. The spread, on any time scale, of plants or animals from any point of origin or from one place to another.

Dispersion Evaluation Area. RG. An area of land defined by topographic features, such as stream drainages, that are typically 2,000 to 5,000 acres in size, but do not exceed 10,000 acres.

Diversity. RG. The distribution and abundance of different plant and animal communities and species within the area covered by a land and resource management plan. See also **Edge**, **Horizontal Diversity**, and **Vertical Diversity.**

Douglas-Fir Type. RG. An association of tree species in which Douglas-fir is recognized as one of the principal seral species.

E

East Side Forests. RG. The ten National Forests of the Pacific Northwest Region that lie east of the Cascade Mountain Range crest: Colville, Deschutes, Fremont, Malheur, Ochoco, Okanogan, Umatilla, Wallowa-Whitman, Wenatchee, and Winema National Forests.

Ecosystem. RG. An interacting system of organisms considered together with their environment; for example, marsh, watershed, and lake ecosystems.

Ecotone. RG. The area influenced by the transition between plant communities or between successional stages or vegetative conditions within a plant community.

Edge. RG. Where plant communities meet or where successional stages or vegetative conditions within plant communityies come together. See also **Edge Contrast** and **Horizontal Diversity.**

Edge Contrast. RG. A qualitative measure of the difference in structure of two adjacent vegetated areas; for example, "low," "medium," or "high" edge contrast.

Effects. RG. Environmental consequences as a result of a proposed action. Included are direct effects, which are caused by the action and occur at the same time and place, and indirect effects, which are caused by the action and are later in time or further removed in distance, but which are still reasonably foreseeable. Indirect effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.

Effects and impacts as used in this statement are synonymous. Effects include ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic quality, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. Effects may also include those resulting from actions that may have both beneficial and detrimental effects, even if on balance the agency believes that the effects will be beneficial (40 CFR 1508.8).

Endangered Species. RG. Any species of animal or plant that is in danger of extinction throughout all or a significant portion of its range. Plant or animal species identified by the Secretary of the Interior as endangered in accordance with the 1973 Endangered Species Act.

Environmental Analysis. RG. An analysis of alternative actions and their predictable short- and long-term environmental effects, incorporating the physical, biological, economic, social, and environmental design arts and their interactions.

Environmental Assessment. RG. A concise public document required by the regulations implementing the National Environmental Policy Act.

Epiphyte. RG. A plant that grows upon another plant and that is nonparasitic. Most of the plant's necessary moisture and nutrients are derived from the atmosphere.

Even-Aged Management. RG. The application of a combination of actions that results in the creation of stands in which trees of essentially the same age grow together. Managed even-aged forests are characterized by a distribution of stands of varying ages (and, therefore, tree sizes) throughout the forest area. The difference in age between trees forming the main canopy level of a stand usually does not exceed 20 percent of

the age of the stand at harvest rotation age. Regeneration in a particular stand is obtained during a short period at or near the time that a stand has reached the desired age or size for regeneration and is harvested. Clearcut, shelterwood, or seed tree cutting methods produce even-aged stands.

Exclusion Area. RG. An area having a statutory prohibition to rights-of-way for linear facilities or corridor designation.

Extended Rotation. SAF. A period of years that is longer than the time necessary to grow timber crops to a specified condition of maturity. See **Rotation.**

Extended Rotation Age. SAF. A point in time when trees are harvested or planned to be harvested which is beyond the age when harvest ordinarily would occur. See **Rotation Age.**

Existing Utility Corridor. RG. A strip of land containing one or more existing linear utility rights-of-way, which is or will be designated in Forest planning in order to facilitate future authorization of additional utility rights-of-way.

Extensive Forest Management. RG. A low investment level of management on regulated timberlands that requires initial harvest, regeneration, and final harvest. Some precommercial thinning may be done to prevent stagnation and disease buildup.

Extirpation. See **Extinct.**

Extinct. EFG. A species is extinct when it no longer exists; also refered to as extirpated.

F

FORPLAN. A Forest planning model. It is a linear computer program used to analyze planning decisions concerning land use patterns, capital investments and the scheduling of events such as timber harvests.

Fledge. WEB. To acquire the feathers necessary for flight; to rear until ready for flight or independent activity.

Floodplain. RG. The lowland and relatively flat areas adjoining inland and coastal waters (including debris cones and floodprone areas of offshore islands) including, at a minimum, those areas subject to a 1-percent or greater chance of flooding in any given year (100-year recurrence).

Forage. RG. All browse and nonwoody plants available to livestock or wildlife for grazing or harvested for feed.

Foreground. RG. A term used in visual management to describe the stand of trees immediately adjacent to a high-value scenic area, recreation facility, or forest highway. See **Background, Middleground.**

Forest Fragmentation. The change in the forest landscape, from extensive and continuous forests of old growth to a mosaic of younger stand conditions.

Forest Product Utilization (FPU). RG. A program of utilization during the cutting and removal of forest products that have some personal or commercial value.

Forest Residues (Logging). RG. The unused portions of sawtimber and poletimber trees cut or killed by logging.

Forest Types. RG. A classification of forest land based upon the tree species presently forming a plurality of basal area stocking in live trees.

Free-to-Grow. RG. A term used by silviculturalists to indicate that trees are free of growth restraints, the most common of which is competing over-topping vegetation.

Further Planning Areas. RG. Areas designated by the RARE II process for further study to determine their use for wilderness or other resource management and development. This will be done during the development of the Forest Plans.

G

Genetic Drift. WEB. Changes of gene frequency in small populations due to chance preservation or extinction of particuliar genes.

Genetic Integrity. RG. Refers to a normal, healthy genetic pool (foundation) within a biological population to provide for long-term maintenance and survival of the species. Of specific concern in management direction is the prevention of loss of genetic variance (heterozygosity) and the avoidance of inbreeding depression, an important part of a given population's genetic integrity within the gene pool.

Goal. RG. A concise statement that describes a desired condition to be achieved sometime in the future. It is normally expressed in broad, general terms and is timeless in that it has no specific date by which it is to be completed. Goal statements form the principal basis from which objectives are developed.

Goods and Services. RG. The various outputs, including onsite uses, produced from forest and rangeland resources.

Grass-Forb. A seral stage in which grass and forbs (herbs) are predominant.

Group Selection Cutting. RG. Removal of tree groups ranging in size from a fraction of an acre up to about 2 acres. Area cut is smaller than the minimum feasible under even-aged management for a single stand.

Guideline. RG. An indication or outline of policy or conduct that is not a mandatory requirement (as opposed to a standard, which is mandatory).

H

Habitat. RG. The place where a plant or animal naturally or normally lives and grows.

Harvest Cutting Method. RG. A combination of interrelated actions whereby forests are tended, harvested, and replaced. The combination of management practices used to manipulate the vegetation results in forests of distinctive form and character. Harvest cutting methods are classified as even-aged and uneven-aged.

Herbaceous. RG. An adjective describing seed-producing plants that do not develop persistent woody tissue, but die down to ground level at the end of the growing season.

Heterozygosity. RG. Genetic variance (Data from natural populations reflect strong support for the theory that heterozygous individuals have a greater viability and often fecundity than do homnozygous individuals).

Home Range. EFG. A restricted area to which the activities of an animal are confined; it is known as a territory when actively defended.

Horizontal Diversity. RG. The distribution and abundance of plant and animal communities or successional stages across an area of land; the greater the number of communities, the higher the degree of horizontal diversity. This concept is close to, but not exactly the same as, "even-aged management," although each may influence the other. Application of even-aged management, for example, can be designed to accomplish horizontal diversity objectives. See also **Vertical Diversity.**

Hydrologic. RG. Pertaining to the quantity, quality, and timing of water yield from forested lands.

Hypothesis. See **Theory.** WEB. A tentative assumption made to draw out and test its logical or emperical consequences. Hypothesis implies insufficiency of presently attainable evidence and therefore a tentative explaination.

Hypothetical. See **Theoretical.** WEB. Involving a logical hypothesis.

I

Inbreeding. WEB. The interbreeding of closely related individuals.

Inbreeding Depression. RG. In wildlife populations, the occurrence of viable offspring decreases as inbreeding increases. The effects of inbreeding depression can be measured by three means: 1) survival rates--offspring fail to survive to maturity; 2) natality success or fecundity depression--inbred wildlife populations are more likely to be sterile than outbred populations and inbred parents are poorer parents than outbred parents; 3) sex ratio depression--as inbreeding increases, the male of the species becomes more common among surviving offspring.

Interagency Spotted Owl Subcommittee. A subcommittee of the Oregon-Washington Interagency Wildlife Committee that was formed to recommend guidelines to Federal land management agencies for the protection of the northern spotted owl.

Integrated Pest Management. RG. A process for selecting strategies to regulate forest pests in which all aspects of a pest-host system are studied and weighed. The information considered in selecting appropriate strategies includes the impact of the unregulated pest population on various resource values, alternative regulatory tactics and strategies, and benefit/cost estimates for these alternative strategies. Regulatory strategies are based on sound silvicultural practices and ecology of the pest-host system and consist of a combination of tactics such as timber stand improvement plus selective use of pesticides. A basic principle in the choice of strategy is that it be ecologically compatible or acceptable.

Intensive Forest Management. RG. A high investment level of timber management that envisions initial harvest, regeneration with genetically improved stock, control of competing vegetation, fill-in planting, precommercial thinning as needed for stocking control, one or more commercial thinnings, and final harvest.

Interdisciplinary Approach. RG. Using individuals representing two or more areas of knowledge and skills focusing on the same tasks, problem, or subject.

Intermingled Ownerships. RG. Lands within the National Forest boundaries or surrounded by National Forest lands that are owned by private interests or other government agencies. Because of early land grants, these lands frequently are in checkerboard ownership patterns.

Interspecific Competition. WPG. The condition of rivalry that exists when a number of organisms of different species use common resources that are in short supply; or, if the resources are not in short supply, the condition that occurs when the organisms seeking that resource nevertheless harm one or another in the process. Competition is usually confined to closely related species which eat the same sort of food or live in the same sort of places. Competition typically results in ultimate elimination of the less effective organism from that ecological niche.

Intervener. WEB. One who intervenes, especially one who intervenes as a third party in a legal proceeding. See **Appellant**.

Irretrievable. RG. Applies to losses of production, harvest, or use of renewable natural resources. For example, some or all of the timber production from an area is irretrievably lost during the time an area is used as a winter sports site. If the use is changed, timber production can be resumed. The production lost is irretrievable, but the action is not irreversible.

Irreversible. RG. Applies primarily to the use of nonrenewable resources, such as minerals or cultural resources, or to those factors, such as soil productivity, that are renewable only over long time periods. Irreversible also includes loss of future options.

Isolate. A population that is isolated. See **Isolation.**

Isolation. SAF. Absence of genetic crossing among populations because of distance or geographic barriers.

Issues. RG. A point, matter, or question of public discussion or interest to be addressed or decided through the planning proces.

K

Kuchler Vegetative Types. RG. Potential natural vegetation of the coterminous United States, classified by Kuchler.

L

Landownership Pattern. RG. The National Forest System resource land base in relation to other landownerships within given boundaries.

Large Sawtimber. A stand condition in which the average tree diameter exceeds 20 inches.

Long-term Sustained-Yield Timber Capacity. RG. The highest uniform wood yield from lands being managed for timber production that may be sustained under a specified management intensity consistent with multiple-use objectives.

M

M. RG. Thousand.

MBF. RG. One thousand board feet. Lumber or timber measurement term.

MM. RG. Million.

MMBF. A lumber or timber measurement term. A million board feet.

Managed. Refers to any National Forest land, including owl habitat, that is harvested on a scheduled basis and contributes to an allowable sale quantity.

Management Concern. RG. An issue, problem, or a condition which constrains the range of management practices identified by the Forest Service in the planning process.

Management Direction. RG. A statement of multiple-use and other goals and objectives, the associated management prescriptions, and standards and guidelines for attaining them.

Management Intensity. RG. A management practice or combination of management practices and associated costs designed to obtain different levels of goods and services.

Management Practice. RG. A specific activity, measure, course of action, or treatment.

Management Prescription. RG. Management practices and intensity selected and scheduled for application on a specific area to attain multiple-use and other goals and objectives.

Market Resources. RG. Products derived from renewable and nonrenewable resources that have a well-established market value, for example, forage, timber, water, and minerals.

Mass Wasting. RG. A general term for any of the variety of processes by which large masses of earth material are moved downslope, either slowly or quickly, by gravitational forces.

Mature. For a given tree species or forest stand, the approximate age beyond which growth declines or decay begins.

Maximum Modification. See **Visual Quality Objectives.**

Mean. SAF. A central value of a series or set of observations obtained by dividing the algebraic sum of all observations in a set by their number.

Mean Annual Increment. RG. The total increment up to a given age divided by that age.

Median. SAF. A central value of a series or set of observations such that equal numbers of observations lie on either side.

Middleground. The visible terrain beyond the foreground where individual trees are still visible, but do not stand out distinctly from the stand. See **Foreground** and **Background.**

Midstory. That area in a stand of trees that is between the upper branches or crown and the lower level of forest growth.

Minimum Viable Population. RG. The low end of the viable population range.

Mixed Conifer. As used in this document, the term, mixed conifer, refers to those stands of trees, made up of pine, Douglas-fir, and true firs, that are generally found east of the Cascades.

Modal. WEB. Of or relating to a statistical **mode.**

Mode. WEB. The most frequent value of a set of data.

Model. WPG. 1) An idealized representation of reality for purposes of describing, analyzing, or understanding the behavior of some aspect of

it. The term model is applicable to a broad class of representations, ranging from a relatively simple qualitative description of a system or organization to a highly abstract set of mathematical equations. 2) A representation of the relationships under study. A model may be a set of mathematical equations, a computer program, or any other type of representation, ranging from verbal statements to physical objects. 3) A simplified representation of an operation, containing only those aspects that are of primary importance to the problem under study.

Modification. See **Visual Quality Objectives.**

Monitoring. RG. A process to collect significant data from defined sources to identify departures or deviations from expected plan outputs.

Morphology. EFG. The study of form and its development.

Multiple Use. RG. The management of all the various renewable surface resources of the National Forest System so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; that some lands will be used for less than all of the resources; and harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output.

Multivariate Analysis. EF. A field of statistics in which multiple variables are used to compare sample groups. Multivariate analysis contrasts with univariate analysis in which single variables are used to compare sample groups.

Municipal Supply Watershed. RG. A watershed that provides water for human consumption where Forest Service management could have a significant effect upon the quality of water at the intake point and that provides water used by a community, or any other public water system that regularly serves at least 25 individuals at least 60 days out of the year or that provides at least 15 service connections.

N

NAAQS. RG. National Ambient Air Quality Standards.

NEPA. RG. National Environmental Policy Act of 1969.

NF. RG. National Forest.

NFMA. RG. National Forest Management Act of 1976.

National Forest System (NFS) Land. RG. Federal lands that have been designated by Executive order or statute as National Forests, National Grasslands, or Purchase Units, and other lands under the administration of the Forest Service, including Experimental Areas and Bankhead-Jones Title III lands.

Natural Forest. RG. The forest that would occur on the planning area in 50 years if natural processes were allowed to function without man's influence.

New Utility Corridor. RG. A strip of land containing no existing linear utility right-of-way, but warranting designation as a full corridor.

Nitrogen-Fixing (Nitrogen Fixation). RG. Conversion of free nitrogen into combined forms useful in nutrient cycles and other functions in the biosphere.

Nocturnal. EFG. Refering to the darkness; of organisms active or functional at night.

Nonattainment Areas. RG. An area that has been identified in the State Implementation Plan where at least one of the national air-quality standards is violated.

Nonchargeable Timber. RG. Timber volume removed from regulated and unregulated forest land that does not contribute to annual sustained-yield capacity.

Nonconsumptive Use. RG. That use of a resource that does not reduce its supply; for example, nonconsumptive uses of water include hydroelectric power generation, boating, swimming, and fishing.

Nondeclining Even Flow. RG. A policy governing the volume of timber removed from a National Forest, which states that the volume planned for removal in each succeding decade will equal or exceed that volume planned for removal in the previous decade.

Nongame. RG. Species of animals not managed for sport hunting.

Nonmarket. RG. Products derived from National Forest resources that do not have a well-established market value; for example, recreation, wilderness, wildlife.

O

Objective. RG. A concise, time-specific statement of measurable planned results that respond to preestablished goals. An objective forms the basis for further planning to define the precise steps to be taken and the resources to be used in achieving identified goals.

Occupancy Rate. In reference to spotted owls, the percent of inventoried spotted owl habitats that are estimated to be occupied by breeding pairs of spotted owls.

Off-Road Vehicles (ORV's). RG. Vehicles such as motorcycles, all-terrain vehicles, four-wheel drive vehicles, and snowmobiles.

Old-Growth Stand. RG. An old-growth stand is defined as any stand of trees ten acres or greater generally containing the following characteristics: 1) stands contain mature and overmature trees in the overstory and are well into the mature growth stage; 2) stands will usually contain a multilayered canopy and trees of several age classes; 3) standing dead trees and down material are present; and 4) evidence of man's activities may be present, but does not significantly alter the other characteristics and would be a subordinate factor in a description of such a stand.

Ooligist. WEB. 1) One specializing in oology. 2) One who collects birds' eggs.

Oology. WEB. A branch of ornithology dealing with birds' eggs.

Open Sapling Pole. MWFH. Sapling and pole stands which are characterized by an open tree canopy. Crown closure will be less than 60 percent and the trees will exceed ten feet in height.

Optimum Density. RG. For wildlife, the maximum rate of animal stocking possible without inducing damage to vegetation or related resources; may vary from year to year because of environmental and population factors, or both.

Oregon-Washington Interagency Wildlife Committee. A committee composed of administrators from Federal and state agencies; including the USDA Forest Service, the U.S. Fish and Wildlife Service, the Bureau of Land Management, the Oregon Department of Fish and Wildlife, and the Washingon Department of Game.

Output. RG. The goods, end products, or services that are purchased, consumed, or used directly by people. Goods, services, products, and concerns produced by activities that are measurable and capable of being used to determine the effectiveness of programs and activities in meeting objectives. A broad term for describing any result, product, or service that a process or activity actually produces.

Overhead Closure. See **Canopy Closure.**

Overmature. RG. The stage at which a tree declines in vigor and soundness; for example, past the period of rapid height growth.

Overstory. WPG. That portion of the trees in a forest with more than one roughly horizontal layer of foliage which forms the upper or uppermost layer.

P

Parameter. DST. An unknown quantity which may vary over a certain set of values. NAD. a characteristic or defining element.

Persons-At-One-Time (PAOT). RG. The number of people in an area or using a facility at the same time. Generally used as "maximum PAOT" to indicate the capacity of an area or facility to support peak usage within established user density standards and without degradation to biophysical resources.

Physiographic Province. WPG. An area or division of land in which the pattern of topographical elements (such as altitude, relief, and landforms) are characteristic throughout and, as such, are distinguished from other areas with different sets of topographical elements.

Pole. SAF. A young tree of greater than four inches and generally less than eight to 12 inches dbh.

Ponderosa Forest Type. Tree stands made up of ponderosa pine trees. Hardwoods and other conifers may be present in small amounts.

Population Dynamics. SAF. The aggregate of changes that occur during the life of a population. Included are all phases of recruitment and growth, senility, mortality, seasonal fluctuation in the biomass, and persistance of each year class and its relative dominance, as well as the effects that any or all of these factors exert on the population.

Precision. DST. Refers to the way in which repeated observations conform to themselves.

Precommercial Thinning. RG. The practice of removing some of the trees less than merchantable size from a stand so that the remaining trees will grow faster.

Predator. SAF. Any animal that preys externally on others, i.e., that hunts, kills, and generally feeds on a succession of hosts, i.e., the prey.

Prescribed Fire. RG. A wildfire burning under specified conditions that will accomplish certain planned objectives. The fire may result from either planned or unplanned ignitions. Use of unplanned ignitions must have prior approval by the Regional Forester.

Preservation. See **Visual Quality Objectives.**

Presuppression. RG. Activities organized in advance of fire occurrence to ensure effective suppression action.

Primitive. See **Recreation Opportunity Spectrum (ROS).**

Private Industrial Forest Land. RG. Lands owned by companies or individuals operating wood-using manufacturing facilities.

Private Nonindustrial Forest Land. RG. Those forest lands owned by companies or individuals who do not own or operate wood-using manufacturing facilities.

Production Potential. RG. The capability of the land or water to produce a given resource.

Public Issue. RG. A subject or question of widespread public interest relating to management of National Forest System.

Public Paricipation. RG. Meetings, conferences, seminars, workshops, tours, written comments, responses to survey questionnaires, and similar activities designed and held to obtain comments from the public about Forest Service planning.

Purchaser Credit. RG. Credit earned by the purchaser of a National Forest timber sale by construction of contract-specified roads. Earned purchaser credit may be used by the purchaser as payment for National Forest timber removed.

R

RPA. RG. The Forest and Rangeland Renewable Resources Planning Act of 1974. Also refers to the National Assessment and Recommended Program developed to fulfill the requirements of the act. The most recent recommended program was completed in 1980.

Radiotelemetry. NAD. Automatic measurement and transmission of data from remote sources via radio to a receiving station for recording and analysis.

Random. WEB. Being or relating to a set or to an element of a set each of whose elements has equal probability of occurrence; also characerized by procedures to obtain such sets or elements.

Range (of a species). EFG. The area or region over which an organism occurs.

Range (statistical). SAF. An elementary measure of the dispersion of a set of random variables, equal to the largest minus the smallest.

Real Dollar Value. RG. A monetary value which compensates for the effects of inflation.

Recreation Capacity. RG. The number of people that can take advantage of the supply of a recreation opportunity during an established use period without substantially diminishing the quality of the recreation experience or the biophysical resources.

Recreation Opportunity Spectrum (ROS). RG. Land delineations that identify a variety of recreation experience opportunities categorized into six classes on a continuum from primitive to urban. Each class is defined in terms of the degree to which it satisfies certain recreation experience needs, based on the extent to which the natural environment has been modified, the type of facilities provided, the degree of outdoor skills needed to enjoy the area, and the relative density of recreation use. The six classes are:

1. Primitive--Area is characterized by an essentially unmodified natural environment of fairly large size. Interaction between users is very low and evidence of other users is minimal. The area is managed to be essentially free from evedence of human-induced restrictions and controls. Motorized use within the area is not permitted.

2. Semiprimitive Nonmotorized--Area is characterized by a predominantly natural or natural-appearing environment of moderate to large size. Interaction between users is low, but there is often evidence of other users. The area is managed in such a way that minimym onsite controls and restrictions may be present, but would be subtle. Motorized recreation use is not permitted, but local roads used for other resource management activities may be present on a limited basis. Use of such roads is restricted to minimize impacts on recreational experience opportunities.

3. Semiprimitive Motorized--Area is characterized by a predominantly natural or naturl-appearing environment of moderate to large size. Concentration of users is low, but there is often evidence of other users. The area is managed in such a way that minimum onsite controls and restrictions may be present, but would be subtle. Motorized recreation use of local primitive or collector roads with predominantly natural surfaces and trails suitable for motor bikes is permitted.

4. Roaded Natural--Area is characterized by predominantly natural-appearing environments with moderate evidence of the sights and sounds of man. Such evidence usually harmonizes with the natural environment. Interaction between users may be moderate to high, with evidence of other users prevalent. Resource modification and utilization practices are evident, but harmonize with the natural environment. Conventional motorized use is allowed and incorporated into construction standards and design of facilities.

5. Rural--Area is characterized by a natural environment that has been substantially modified by development of structures, vegetative mainpulation, or pastoral agricultural development. Resource modification and utilization practices may be used to enhance specific recreation activities and to maintain vegetative cover and soil.

   Sights and sounds of humans are readily evident, and the interaction between users is often moderate to high. A considerable number of facilities are designed for use by a large number of people. Facilities are often provided for special activities. Moderate user densities are present away from developed sites. Facilities for intensified motorized use and parking are available.

6. Urban--Area is characterized by a substantially urbanized environment, although the background may have natural-appearing

elements. Renewable resource modification and utilization practices are often used to enhance specific recreation activities. Vegetative cover is often exotic and manicured. Sights and sounds of humans are predominant on site. Large numbers of users can be expected both on site and in nearby areas. Facilities for highly intensified motor use and parking are available with forms of mass transit often available to carry people throughout the site.

Recreation Visitor Days (RVD's). RG. Twelve visitor hours, which may be aggregated continuously, intermittently, or simultaneously by one or more persons.

Recruitment. SAF. The addition to a population from all causes,ie., reproduction, immigration, and stocking. Reproduction may refer literally to numbers born or hatched or to numbers at a specified stage of life such as breeding age or weaning age.

Reforestation. RG. The natural or artificial restocking of an area with forest trees; most commonly used in reference to artificial restocking.

Regeneration. RG. The actual seedling and saplings existing in a stand; or the act of establishing young trees naturally or artificially.

Regulations. RG. Generally refers to the Code of Federal Regulations, Title 36, Chapter II, which covers management of the Forest Service.

Residual Stand. RG. The trees remaining standing after some event such as selection cutting.

Residue Loading. RG. The quantity of the unwanted accumulation in the forest of living or dead, mostly woody material that is added to and rearranged by man's activities, such as forest harvest, cultural operations, and land clearing. Forest residue includes slash materials, excessive litter on the forest floor, unwanted living brush and weed trees, and standing dead trees and snags.

Residue Utilization. RG. Removal and use of forest residue (such as slash, litter, brush, dead trees, and snags) for energy production, home heating, or wood products.

Resource Use and Development Opportunities. RG. A possible action, measure, or treatment and corresponding goods and services identified and introduced during the scoping process, which subsequently may be incorporated into and addressed by the Forest Land and Resource Management Plan in terms of a management prescription.

Riparian Area. RG. A geographically delineated area with distinctive resource values and characteristics that comprises aquatic and riparian ecosystems. This includes floodplains, wetlands, and all areas within a horizontal distance of approximately 100 feet from the normal line of high water of a stream channel or from the shoreline of a standing body of water.

Roadless Area Review and Evaluation (RARE II). RG. A comprehensive process directed by the Secretary of Agriculture to identify roadless and undeveloped land areas in the National Forest system and to determine their uses for either wilderness or other resource management and development and to determine areas that would require further planning to make such a decision.

Rotation. SAF. The planned number of years between the formation or the regeneration of a crop or stand of trees and its final cutting at a specified stage of maturity.

Rotation Age. RG. The age of a stand when harvested at the end of a rotation.

S

SCORP. RG. Statewide Comprehensive Outdoor Recreation Plan.

SOHA (Spotted Owl Habitat Area). See **Designated Habitat Area.** A habitat area designated to support one pair of owls.

SOMA (Spotted Owl Management Area). See **Designated Habitat Area.** A habitat area designated to support more than one pair of owls.

S&PF. RG. State and Private Forestry Assistance Program.

Sample. SAF. A part of a population, consisting of one or more sampling units, selected and examined as representative of the whole.

Sampling Intensity. The number of sampling units which are to be included in the sample per unit of area to be sampled.

Sanitation Salvage. RG. The removal of dead, damaged, or susceptible trees primarily, essentially to prevent the spread of pests or pathogens and promote forest hygiene.

Sapling. SAF. A loose term for a young tree no longer a seedling, but not yet a pole. It is generally a few feet high and an inch or so dbh, typically growing vigorously and without dead bark or more than an occasional dead branch. In the U.S., a sapling is two to four inches dbh.

Saprophyte. RG. A plant living on dead or decaying organic matter.

Saturation Density. RG. (Same as tolerance density) Intraspecific tolerance permits no future increase. Is most marked in territorial species. Space is the limiting factor to the further increase of this population density.

Scope. CFR. Consists of the range of actions, alternatives, and impacts to be considered in an environmental impact statement.

Second Growth. RG. Forest growth that has come up naturally after some drastic interference (for example, wholesale cutting, serious fire, or insect attack) with the previous forest growth.

Semiprimitive Motorized ROS Class. See **Recreation Opportunity Spectrum.**

Semiprimitive Nonmotorized ROS Class. See **Recreation Opportunity Spectrum.**

Sensitive Species. RG. Those species that have appeared in the Federal Register as proposed for classification and are under consideration for official listing as endangered or threatened species, that are on an official State list, or that are recognized by the Regional Forester as needing special management to prevent their being placed on Federal or State lists.

Seral. RG. A biotic community that is a developmental, transitory stage in an ecological succession.

Series. RG. A level of vegetation classification that is identified by the most common species found in the tree, shrub, and/or herbaceous layer of a plant community. Series is a subdivision of a subformation.

Sexual Dimorphism. EF. The differences in size, weight, color, or other morphological characteristics that are related to the sex of the animal. See **morphology.**

Shade-Intolerant Plants. RG. Plant species that do not germinate or grow well in shade.

Shade-Tolerant Plants. RG. Plants that grow well in shade.

Shelterwood. SAF. An even-aged silvicultural system in which, in order to provide a source of seed or protection for regeneration or both, the old crop (the shelterwood) is removed in two or more successive shelterwood cuttings, the first of which is ordinarily the seed cutting and the last is the final cutting, with any intervening cutting being termed removal cutting.

Shrub. MWFH. A stand condition where shrubs are the dominant vegetation. Tree regeneration may be common, but trees are generally less that ten feet tall and provide less than 30 percent of crown cover.

Sikes Act. OLR. The Sikes Act (Extension of 1974) mandates comprehensive plans to plan develop, maintain, and coordinate programs for the conservation and rehabilitation of wildlife. fish, and game. The Act allows cooperative agreements between the States and the Forest Service for planning and implementing wildlife habitat construction and improvement projects.

Silviculture. RG. The art and science of controlling the establishment, composition, and growth of forests.

Skyline Deflection. RG. The distance a skyline cable drops below line of sight during the yarding operation.

Skyline Logging. RG. A system of cable logging in which all or part of the weight of the logs is supported during yarding by a suspended cable.

Skyline Tailhold. RG. Anchors consisting of stumps, trees, deadmen, or rock bolts to hold the end of the skyline yarding cable that is opposite the yarding machine.

Slash. RG. The residue left on the ground after timber cutting and/or accumulating there as a result of storm, fire, or other damage. It includes unused logs, uprooted stumps, broken or uprooted stems, branches, twigs, leaves, bark, and chips.

Small Game. RG. Birds and small mammals typically hunted or trapped.

Snag. GET. A standing dead tree.

Species. EFG. A group of individuals that have their major characteristics in common and are potentially interfertile.

Socioeconomic. RG. Pertaining to, or signifying the combination or interaction of, social and economic factors.

Stand (Tree Stand). RG. An aggregation of trees occupying a specific area and sufficiently uniform in composition, age arrangement, and condition as to be distinguishable from the forest in adjoining areas.

Standard Error (SE). DST. The positive square root of the variance of the sampling distribution of a statistic. It is a measure of the variation around the mean.

Stand Condition. SAF. The state of health of a stand of trees. May also include a description of the stand's physical properties such as crown closure or diameter of the stem.

Starch-Gel Electrophoresis. EF. A chemical process in which protein from blood or tissues samples are separated and stained in a starch-gel medium. The stained protein bands are then examined to determine if a group or population is polymorphic (multiformed) for a given protein.

Stereotyped Behavior. EF. Behavior that tends to be repeated without variation.

Stocking. RG. The degree of occupancy of land by trees as measured by basal area or number of trees and as compared to a stocking standard; that is, the basal area or number of trees required to fully use the growth potential of the land.

Subsistence Density. RG. A population obtaining enough food for bare survival, but not enough to maintain a healthy population over time. This population density should be regarded as a disaster level.

Subspecies. EFG. A population of a species occupying a particular geographic area, or less commonly, a distinct habitat, capable of interbreeding with other populations of the same species.

Successional Stage. RG. A stage or recognizable condition of a plant community that occurs during its development from bare ground to climax; for example, coniferous forests in the Blue Mountains progress through six recognized stages: grass-forb; shrub-seedling; pole-sapling; young; mature; old-growth.

Suitable Habitat. The timber-type preferred by spotted owls as habitat and which is presently in the successional stage usable for owls.

Suitability. RG. The appropriateness of applying certain resource management practices to a particular area of land, as determined by an analysis of the economic and environmental consequences and the alternative uses foregone. A unit of land may be suitable for a variety of individual or combined management practices.

Suppression. RG. The action of extinguishing or confining a fire.

Sustained Yield of the Products and Services. RG. The achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the National Forest System without impairment to the productivity of the land.

Survivorship. EFG. The proportion of newborn individuals which are alive at a given age.

T

Taxonomy. SAF. The science of classifing organisms according to natural relationships, based mainly on morphological criteria.

Theoretical. WEB. Relating to or having the character of theory. See **hypothetical.**

Theory. WEB. A plausible or scientifically acceptable general principle or body of principles offered to explain phenomena. See **hypothesis.**

Thermal Cover. Cover used by animals to lessen the effects of weather; for elk, a stand of coniferous trees 40 feet or more tall with an average crown closure of 70 percent or more.

Thermoregulation. EF. The physiological and biological process whereby an animal regulates its body temperature.

Threatened Species. RG. Those plant or animal species likely to become endangered species throughout all or a significant portion of their range within the foreseeable future. A plant or animal species identified by the Secretary of Interior as threatened in accordance with the 1973 Endangered Species Act.

Timber Classification. RG. Forested land is classified under each of the land management alternatives according to how it relates to the management of the timber resource. The following are definitions of timber classifications used for this purpose.

1. Nonforest--Land that has never supported forests and land formerly forested where use for timber production is precluded by development or other uses.

2. Forest--Land at least 10 percent stocked (based on crown cover) by forest trees of any size, or formerly having had such tree cover and not currently developed for nonforest use.

3. Suitable--Commercial forest land identified as appropriate for timber production in the Forest planning process.

4. Unsuitable--Forest land withdrawn from timber utilization by statute or administrative regulation (for example, wilderness), or identified as not apprpriate for timber production in the Forest planning process.

5. Commercial Forest--Forest land tentatively suitable for the production of continuous crops of timber and that has not been withdrawn.

Timber Harvest Schedule. RG. The quantity of timber planned for sale and harvest, by time period, from the area of land covered by the Forest Plan. The first period, usually a decade, of the selected harvest schedule provides the allowable sale quantity. Future periods are shown to establish that sustained yield will be achieved and maintained.

Timber Production. RG. The purposeful growing, tending, harvesting, and regeneration of regulated crops of trees to be cut into logs, bolts, or other round sections for industrial or consumer use other than for fuelwood.

Timbershed. RG. A geographical grouping of forest lands that historically have provided logs to a centralized area of use.

Timber Stand Improvement. RG. Measures such as thinning, pruning, release cutting, prescribed fire, girdling, weeding, or poisoning of unwanted trees aimed at improving growing conditions for the remaining trees.

U

Understory. WPG. The trees and other woody species growing under a more or less continous cover of branches and foliage formed collectively by the upper portions of adjacent trees and other woody growth.

Uneven-Aged Management. RG. The application of a combination of actions needed to simultaneously maintain continuous high-forest cover, recurring regeneration of desireable species, and the orderly growth and development of trees through a range of diameter or age classes to provide a sustained number or proportion of trees of particular sizes to retain within each area, thereby maintaining a planned distribution of size classes. Cutting methods that develop and maintain uneven-aged stands are single-tree selection and group selection.

Unregulated Timber Management. RG. Timber cut from those lands that are not organized to provide sustained yields of timber.

Urban and Other Areas. RG. Areas within the legal boundaries of cities and towns; suburban areas developed for residential, industrial, or recreational purposes; school yards; cemeteries; roads; railroads; airports; beaches; powerlines and other rights-of-way; or other nonforest land not included in any other land-use class.

Utility and Transportation Corridors. RG. A strip of land designated for the transportation of energy, commodities, and communications by railroad, State highway, electrical power transmission (69 kV and above), oil and gas and coal slurry pipelines ten inches in diameter and larger, and tele-communication cable and electronic sites for interstate use. Transportation of minor amounts of power for short distances, such as short feeder lines from small power projects including geothermal or wind, or to serve custormer subservice substations along the line, are not to be treated within the Forest Plan effort.

Utilization Standards. RG. Standards guiding the use and removal of timber, which is measured in terms of diameter at breast height (d.b.h.), top diameter inside the bark (top d.i.b.), and percent "soundness" of the wood.

V

Vector. RH. A mathematical term. A vector is a quantity, possessing both magnitude and direction, represented by an arrow, the direction of which indicates the direction of the quantity and the length of which is proportional to the magnitude.

Vertical Diversity. RG. The diversity in a stand that results from the complexity of the aboveground structure of the vegetation; the more tiers of vegetation or the more diverse the species makeup (or both), the higher the degree of vertical diversity. This concept is close to but not exactly the same as "uneven-aged management," although each may influence the other. Application of even-aged management, for example, can be designed to accomplish vertical diversity objectives. See also **Horizontal Diversity.**

Viability. EFG. The capability for living and developing.

Viable Population. RG. The number of individuals of a species required to ensure the long-term existence of the species in natural, self-sustaining populations adequately distributed throughout their region.

Visual Quality Objectives (VQO's). RG. Categories of acceptable landscape alteration measured in degrees of deviation from the natural-appearing landscape.

1. Preservation--Ecological change only here.

2. Retention--Human activities are not evident to the casual Forest visitor.

3. Partial Retention--Human activity may be evident, but must remain subordinate to the characteristic landscape.

4. Modification--Human activity may dominate the characteristic landscape, but must, at the same time, follow naturally established form, line, color, and texture. It should appear as a natural occurrence when viewed in foreground or middleground.

5. Maximum Modification--Human activity may dominate the characteristic landscape, but should appear as a natural occurrence when viewed as background.

Visual Resource. RG. The composite of basic terrain, geologic features, water features, vegetative patterns, and land-use effects that typify a land unit and influence the visual appeal the unit may have for visitors.

Vole. NAD. Any rodent of the genus Microtus and related genera, which resemble rats or mice, but having a relatively short tail.

W

West Side Forests. RG. The nine National Forests of the Pacific Northwest Region that lie west of the Cascade Mountain Range crest. They are the Gifford Pinchot, Mt. Baker-Snoqualmie, Mt. Hood, Olympic, Rogue River, Siskiyou, Siuslaw, Umpqua, and Willamette National Forests.

Wetlands. RG. Areas that are inundated by surface water or groundwater with a frequency sufficient to support, and under normal circumstances does or would support, a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction (Executive Order 11990).

Wilderness. RG. Areas designated by congressional action under the 1964 Wilderness Act. Wilderness is defined as undeveloped Federal land retaining its primeval character and influence without permanent improvements or human habitation. Wilderness areas are protected and managed to preserve their natural conditions, which generally appear to have been affected primarily by the forces of nature, with the imprint of human activity substantially unnoticeable; have outstanding opportunities for solitude or for a primitive and confined type of recreation; include at least 5,000 acres or are of sufficient size to make practical their preservation, enjoyment, and use in an unimpaired condition; and may contain features of scientific, educational, scenic, or historical value as well as ecologic and geologic interest.

Wild and Scenic Rivers. RG. Those rivers or sections of rivers designated as such by congressional action under the 1968 Wild and Scenic Rivers Act, as supplemented and amended, or those sections of rivers designated as wild, scenic, or recreational by an act of the Legislature of the State or States through which they flow. Wild and scenic rivers may be classified and administered under one or more of the following categories:

1. Wild River Areas--Those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America.

2. Scenic River Areas--Those rivers or sections of rivers that are free of impoundments, with watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.

3. Recreational River Areas--Those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.

Wildfire. RG. Any wildland fire that is not a prescribed fire. All wildfires require suppression.

Wildland. RG. Uncultivated land, other than fallow, virtually uninfluenced by human activity. It may be neglected altogether or maintained for such purposes as wood or forage production, wildlife habitat, recreation, or protective plant cover.

Windfall. RG. A tree thrown or the stem or other parts (such as branches, foliage, or fruit) broken off or blown down by the wind.

Wingloading. EF. The ratio of body weight to the surface area of the wing. A small body and large wing indicate a low wingload and a large body and small wing indicate a high wingload.

Y

Yarding. RG. The moving of logs from the stump where cut to a central concentration area or landing.

Appendix G

CITED LETTERS

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20250

March 8, 1985

SUBJECT: USDA Decision on Review of Administrative Decision by Chief of the Forest Service related to the Administrative Appeal of the R-6 Regional Guide and EIS

TO: R. Max Peterson
Chief
Forest Service

This is a review of a decision by the Chief of the Forest Service dated June 14, 1984, pursuant to 36 CFR 211.18(f)(1)(iv) on an administrative appeal brought by the National Wildlife Federation, the Oregon Wildlife Federation, the Lane County Audubon Society, and the Oregon Natural Resources Council./1 Appellants and intervenors raise issues concerning alleged inadequacies in the Chief's decision and in the procedure leading to that decision. These issues relate solely to the Region 6 Regional Guide's treatment of the northern spotted owl. No other element of the Regional Guide was challenged; therefore, all other portions of the Guide are considered final. The principal issues are whether the Regional Guide and accompanying Environmental Impact Statement (EIS) adequately complied with the requirements of the National Environmental Policy Act and the requirements of the National Forest Management Act regulations for assuring sufficient habitat for the northern spotted owl to maintain a viable population.

Specific issues raised by the appellants include:

1. The spotted owl management guidelines failed to consider, or require consideration of, the cumulative impacts of timber harvesting on the spotted owl.

/1 Subsequent to filing of the Notice of Appeal and Statement by Reasons by appellants, intervention was granted upon request, 36 CFR 211.18(1)(1), (1) to Seattle Audubon Society who subsequently joined appellants in their reply to the Chief's responsive statement, (2) to Northwest Pine Association, and (3) to Industrial Forestry Association who filed separate replies to the Chief's responsive statement.

2. The Forest Service has not conducted research to fill data gaps and to eliminate uncertainties regarding the likely impacts of timber harvesting on the spotted owl.

3. The Forest Service has not considered the worst case possibilities of proceeding with its current harvesting activities in the face of inadequate knowledge.

BACKGROUND

Pursuant to the Multiple-Use Sustained-Yield Act of 1960 (16 USC 528-531), the Secretary of Agriculture is required:

> "to develop and administer the renewable surface resources of the national forests for multiple use and sustained yield of the several products and services obtained therefrom. In the administration of the national forests due consideration shall be given to the relative values of the various resources in particular areas." (16 USC 529)

"Multiple use" is defined in the Act as:

> "(t)he management of all the various renewable surface resources of the national forests so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in the use to conform to changing needs and conditions ... with consideration being given to the relative values of the various resources .... " (16 USC 531)

By Section 6 of the Forest and Rangeland Renewable Resources Planning Act of 1974, as amended by the National Forest Management Act of 1976, the Secretary of Agriculture is required to develop, maintain and revise land and resource management plans for the national forests and national grasslands. Section 6(g) of the Act requires the Secretary to:

> "promulgate regulations, under the principles of the Multiple-Use Sustained-Yield Act of 1960, that set out the process for the development and revision of the land management plans, and the guidelines and standards prescribed by this subsection." (16 USC 1604(g))

Subsection (g) goes on to specify, among other things, that the regulations:

> "provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple use objectives...." (16 USC 1604(g)(3)(B))

The Secretary has duly promulgated the required regulations in 36 CFR part 219 (hereinafter referred to as the "NFMA regulations"). Section 219.4(b)(2) requires that the Chief of the Forest Service approve a regional guide.

The Regional Forester for the Pacific Northwest Region, Forest Service Region 6, duly developed the regional guide which was approved by the Chief in a Record of Decision and final Environmental Impact Statement dated June 14, 1984. Among the major issues and management concerns addressed by the Regional Guide, the Environmental Impact Statement, and the Record of Decision was habitat management for the northern spotted owl. That management concern was responsive to Section 219.19 of the NFMA regulations dealing with fish and wildlife resources, to Section 219.26 dealing with diversity of plant and animal communities and tree species, and to Section 219.27 which sets forth minimum requirements to be met in managing the National Forest System, including minimum requirements for maintaining plant and animal community diversity and viable populations of wildlife.

CHARACTERISTICS OF THE SPOTTED OWL

The spotted owl (Strix occidentalis) is a medium-sized owl, highly secretive and nocturnal in its habits, which lives in portions of the forested areas of western North America. The most southern and eastern race, Strix occidentalis lucida, ranges north from central Mexico into the mountains of central and western New Mexico, central and southwestern Colorado, extreme southern Utah, and western Arizona. The species type, Strix occidentalis occidentalis, occurs in California from the Mexican border north in the coast ranges to Monterey Bay, and north on the west slope of the Sierra Nevada. The northern race, Strix occidentalis caurina, occupies territory from San Francisco Bay northward in the coast ranges and the Cascade mountains into southern British Colombia. Thus, the forest types occupied by the various races of the spotted owl vary from the temperate rain forests of the Pacific Northwest to the dry pine-type forests of the Southwest and Mexico./2

/2 Wildlife Monographs: Distribution and Biology of the Spotted Owl in Oregon, Eric D. Forsman, E. Charles Meslow, and Howard M. Wight; publication No. 87 of the Wildlife Society, April 1984.

Prior to 1970, very little was known about the northern spotted owl. There had been relatively few reported sightings of this subspecies./3 During the 1970s as a result of the efforts of a number of researchers -- most notably Forsman -- considerable information about the population of northern spotted owls, particularly in Oregon, began to accumulate and some tentative conclusions were drawn concerning the habitat needs of the subspecies. It was apparent that the northern spotted owl had a decided preference for old growth forests as its preferred habitat; quite possibly old growth forests are its required habitat.

FOREST SERVICE RESPONSE TO CONCERN OVER MANAGEMENT OF SPOTTED OWL HABITAT

The Forest Service responded early to concerns expressed about the potential endangerment of the northern spotted owl from ongoing harvest of old growth timber in the Pacific Northwest. By 1979 a Spotted Owl Management Plan, designed by the Oregon Endangered Species Task Force, (now the Oregon-Washington Interagency Wildlife Committee),/4 had been adopted by the Forest Service. One or more of the appellants here had at that time challenged adoption of the Spotted Owl Management Plan by the Regional Forester without preparation of an Environmental Impact Statement. That challenge was disposed of by a Chief's decision of August 11, 1980. In his decision the Chief pointed out that NFMA specifically permitted management of national forest lands to continue under existing land use and resource plans. Thus, until a forest plan was developed pursuant to NFMA and the regulations thereunder, there was no requirement to provide for spotted owl management.

So adoption of the Spotted Owl Management Plan by the Regional Forester at that time was a voluntarily assumed and not a legally required constraint on forest management. The Chief pointed out that the spotted owl was being treated as a sensitive species in Region 6 and that Forest Service policy for sensitive species was to provide special management so as to prevent placement of the species on the federally threatened or endangered species list. The Chief's decision went on to affirm that spotted owl management was to be one of the many elements to be considered in regional and forest plans and that the Regional Guide would include a proper biological analysis to determine the number and distribution of spotted owls which constitute a viable population.

/3 Ibid.

/4 The spotted owl is presently listed as a threatened species by the State of Oregon and a sensitive species by the State of Washington. The spotted owl is not a federally endangered species, but is a management indicator species for the purpose of forest plans in Region 6.

The Regional Guide, which was approved by the Chief on June 14, 1984, and is here under appeal, addresses considerable attention to management of the northern spotted owl. In fact the Guide prescribes a minimum number of spotted owl pairs to be provided in Region 6. Based on that number, shares are allocated to each of the Region 6 forests upon which spotted owl populations are known to occur. The numbers prescribed are essentially derived from the Spotted Owl Management Plan originally adopted by the Regional Forester in 1979 and subsequently revised in 1981.

By assigning each forest the minimum number of spotted owl pairs, the regional guide and EIS implicitly are telling each forest that once the assigned number of pairs is met, the rest of the forest is available to be considered for other uses. Conversely, of course, the assignment of specific numbers by the Regional Guide preempts a significant acreage of old growth forest from consideration for uses that are incompatible with management for spotted owl habitat.

ESTABLISHMENT OF MINIMUM MANAGEMENT REQUIREMENTS FOR WILDLIFE AND THE PLANNING UNIT WITHIN WHICH THOSE REQUIREMENTS WILL BE ACHIEVED

The NFMA regulations require that fish and wildlife habitat on the National Forests:

> "be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area. For planning purposes, a viable population shall be regarded as one which has the estimated numbers and distribution of reproductive individuals to insure its continued existence is well distributed in the planning area. In order to insure that viable populations will be maintained, habitat must be provided to support, at least, a minimum number of reproductive individuals and that habitat must be well distributed so that those individuals can interact with others in the planning area." (36 CFR 219.19)

This provision requires that: (1) the Forest Service manage habitats within the planning area to maintain at least minimum viable populations of wildlife, and (2) suitable habitat be distributed so that individual members of a species can interact with others in the planning area. This provision of the NFMA regulations goes beyond the statutory requirements of NFMA which calls only for providing for diversity of plant and animal communities. So long as 36 CFR 219.19 in its present form is part of the NFMA regulations, however, it is a valid exercise of the Secrectary of Agriculture's discretion in managing the National Forests.

The Forest Service has the discretion under 36 CFR 219.19 to determine the area within which wildlife population viability will be evaluated and suitable habitat maintained. The planning area referred to by the regulations is the area covered either by a regional guide or a forest plan (36 CFR 219.3). It would be biologically difficult and, in many cases, impossible to maintain viable populations on each National Forest of all species which may occupy that forest during a typical year. Many species have low population densities and exceedingly large home ranges that extend over areas of Federal, State and private lands. Administrative boundaries have no biological significance to these species.

There are other species which are transient and may occupy portions of a National Forest for a short period of time or where a particular National Forest comprises only a minor part or is on the fringe of the species' range, where it would be impossible to manage the species' habitat to maintain a viable population on that National Forest.

Under Section 219.19 of the NFMA regulations, the Forest Service may, at its discretion, determine whether the area within which a species' habitat will be managed to support viable populations will be a national forest, a group of national forests, or the entire region.

Spotted owls, at least during their juvenile stage, range over wide areas. The Forest Service has established a tentative goal for minimum numbers of spotted owl pairs for which habitat will be provided in the Region. The Forest Service apparently has determined that due to the range and biological nature of the spotted owl, the most appropriate planning area within which to evaluate the habitat needed to maintain spotted owl viability is the total area of suitable and potential spotted owl habitat in Region 6. This is a valid exercise of the agency's discretion.

Neither is the Forest Service constrained from evaluating the contributions of areas outside of Region 6 to spotted owl viability. For example, movement of spotted owls from California may contribute to the genetic viability of spotted owls in Oregon and Washington. That contribution should be considered in evaluating what constitutes a viable population in Region 6.

HABITAT DISTRIBUTION NEEDED TO ACHIEVE A VIABLE POPULATION

The other general requirement of Section 219.19, in addition to maintaining minimum viable wildlife populations, relates to distribution of habitat within the planning area. Under Section 219.19 the Forest Service is required to maintain habitat "to support, at least, a minimum number of reproductive individuals and that habitat must be well distributed so that those individuals can interact with others in the planning area."

Individual members of a species are not normally evenly distributed throughout the species' range, but occur where habitat conditions are favorable within that range. Where a species' preferred habitat conditions are certain forest vegetative characteristics or conditions that depend upon the age of the forest, the distribution of wildlife populations can shift dramatically over time as different areas of the forest progress through various successional stages. These shifts of a species' population distribution over time are a natural phenomenon which commonly occurred in presettlement North American forests. Catastrophic fires, windstorms, and insect epidemics (working singly or in combination) were the primary natural agents which often destroyed large areas of mature forest and caused the forest successional process to start over. Single natural catastrophic events often destroyed old growth forests over thousands or even hundreds of thousands of acres. Most forests in presettlement North America (including most forests of western Oregon and Washington) consisted of a mosaic of forest stands of various ages, each of which was relatively even-aged which originated from such natural events./5

Section 219.19 should not be interpreted to require maintenance of the same distribution of habitats and species that currently exist on the planning area. Such an approach would not be consistent with the reality of natural forest succession. Neither would it provide the flexibility to manage forests for a variety of objectives. Section 219.19 requires only that suitable habitat be reasonably distributed in the planning area (region or national forest, at the discretion of the Forest Service) so that reproductive individuals of a species can interact and a viable population can be provided for in the planning area.

It should be remembered that those portions of Section 219.19 of the NFMA regulations discussed above relate only to providing habitat for minimum viable populations of fish and wildlife./6 The Forest Service, of course,

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/5 For background on forest succession and the diversity requirements of NFMA see "Natural Diversity in Forest Ecosystems," Proceedings of the Workshop, November 29-December 1, 1982, Institute of Ecology, University of Georgia, Athens, Georgia.

/6 Treatment of the fish and wildlife resource in the regulations is different than the other multiple uses, in that it is the only resource for which minimum production levels are specified by regulation, i.e. habitat necessary to support minimum viable populations must be provided regardless of impacts on other resources uses. Production levels for other multiple uses are established through the planning process with no mandated minimums specified by regulation.

has an obligation to evaluate, and the flexibility to adopt, planning alternatives that would provide for achieving wildlife objectives considerably beyond minimum viable population levels. It is through the forest planning process that decisions on resource objectives and production levels for all the various multiple uses, including wildlife, will be arrived at.

Since the Forest Service has elected to evaluate spotted owl viability on a regional level, coordination among the various National Forests in Region 6 having suitable spotted owl habitat will be required to ensure that habitat is reasonably distributed within the range of the spotted owl in Region 6 so that the viability of the owl in the Region is maintained.

DEALING WITH UNCERTAINTY IN ESTABLISHING MINIMUM MANAGEMENT REQUIREMENTS IN NATIONAL FOREST LAND MANAGEMENT PLANNING

Minimum management requirements (MMRs) are designed to represent minimum standards for Forest Service management, which, if not met, would constitute failure to respond to the intent of law or regulation, e.g. the Endangered Species Act, state air and water quality standards, Section 219.19 requirements for maintaining minimum viable populations of vertebrate species on the planning area, and similar laws and regulations. The process by which MMRs are established is extremely important since they constitute minimum standards that then must be met by each planning alternative.

If MMRs are unnecessarily restrictive, they could significantly limit the "decision space" which should be available to line officers, could make plans vulnerable to successful legal challenge based on grounds that the range of alternatives is unnecessarily restrictive and could involve significant and unnecessary opportunity costs. On the other hand, MMRs that are not sufficient to provide minimal protection to important resource values could result in unwarranted damage to those values and undermine the confidence of the public in management of the National Forests.

Since the scientific basis for establishing MMRs is, in some cases, not as strong as would be desirable, some judgment and subjectivity is necessarily involved. Appellants have contended that the R-6 Regional Guide and EIS do not deal adequately with the scientific uncertainty associated with assessing the amount and characteristics of habitat needed to sustain a viable population of spotted owls. There are at least two sources of uncertainty that must be dealt with in establishing MMRs:

1. Uncertainty as to the possible occurrence of natural events such as storms, unusually severe winters, fires, and insect epidemics, that, in combination with management activities, might create environmental conditions that do not meet minimum water quality, wildlife, fisheries, or similar standards.

2. Uncertainty directly related to a weakness in knowledge about the effects of specific management activities on a particular wildlife species, or on water quality, fisheries or other resource values.

The first type of uncertainty can most effectively be dealt with based on assumed probabilities of certain kinds of natural events occurring and the anticipated consequences if those events were to occur. With respect to wildlife, providing for a variety of habitats which are reasonably distributed will provide a good measure of insurance that such occurrences will not have a major long-term adverse impact on a species.

The second type of uncertainty -- uncertainty based on weakness of the knowledge as to the specific effects of management -- is more difficult to deal with. Since basic knowledge is sometimes weak on the effect of specific management activities on fisheries or water quality on specific soil or topographic types, and on the specific habitat requirements of some wildlife species (such as spotted owls), a considerable amount of subjectivity is necessarily involved in the establishment of MMRs. Although research efforts are being devoted to filling such knowledge gaps, it will be several years before research results are fully available. Even then there are likely still to be some unknowns.

However, the National Forest Management Act provides several mechanisms for dealing with uncertainty in establishing MMRs and in responding to new information on habitat requirements of wildlife.

Section 6(f)(5) of the National Forest Management Act requires that plans be revised at least every fifteen years. The Forest Service currently anticipates that most national forest plans will be revised on a ten year cycle. Therefore, the only irretrievable commitments which will be made, if any, are those that will result from management activities which occur during the ten to fifteen year life of the plan. When the plan is revised, adjustments will be made to reflect current information regarding existing resource inventories, projected resource demands and other information and data that exists at that time, including current information on the habitat requirements of spotted owls and other wildlife species.

Adjustments are possible even before the scheduled revision of the plan. Section 6(g)(3)(C) of NFMA, as implemented by 36 CFR 219.12(k), requires the Forest Service to monitor the implementation of the plan to determine whether the effects that are occurring are similar to those that were anticipated in

the plan. If they are not, revisions or amendments to the management direction contained in the forest plan can be made. Forest Service planning guidelines require that there be a discussion of the details of the monitoring and evaluation plan in the forest plan and EIS.

Section 219.28 of the NFMA regulations also requires the identification of research needed to resolve resource problems and issues identified in the plan. The regulations require that particular attention be given to research needs identified during plan monitoring and evaluation. It may well be preferable, when the value of the resource opportunities are considered, to fund an adequate monitoring program and research effort, than to establish MMRs that are so conservative that significant resource management options that would otherwise be viable are foregone.

In summary, NFMA requirements for monitoring, periodic revision of plans, and identification of needed research, provide a sound way of dealing with uncertainties about both the occurrence of natural events and over the specific habitat requirements of wildlife species which are inherent in the establishment of MMRs.

SIGNIFICANT CONSIDERATIONS IN ADDRESSING THE SPOTTED OWL ISSUE

The following summarizes the major considerations which were relevant to reaching a decision on the disposition of this appeal:

1. The Forest Service's decision that the Region, rather than an individual national forest, is the most appropriate planning area within which to evaluate the habitat needed to maintain spotted owl viability is an appropriate exercise of agency discretion. Therefore, the R-6 Regional Office is the most appropriate Forest Service organizational level to assign primary responsibility for coordinating spotted owl protection efforts.

2. There has been no evidence provided, nor do the Appellants suggest, that spotted owl habitat is being reduced at a rate that would threaten the viability of the species within Region 6 during the next ten years at least. In fact, recent surveys continue to find more owls than previously were thought to exist. Recent research has found that spotted owls are somewhat more adaptable than had been previously anticipated, and possess a greater ability to disperse and travel significant distances while in the juvenile stage to seek out new habitats. The latter characteristic reduces the risk of genetic deterioration in isolated populations.

3. Requirements in NFMA and its implementing regulations for monitoring, periodic revision of plans, and identification of needed research, provide an appropriate approach for dealing with uncertainty associated with establishment of MMRs.

4. Both the Forest Service and several universities have major research initiatives designed to inventory populations and determine habitat requirements of spotted owls and other wildlife associated with old growth forests. In spite of overall reductions during the last four years in funding levels for Forest Service research, funding for the old growth wildlife research project has been increased significantly. It is anticipated that high priority will continue to be placed on this research. This research already has yielded important information and should begin to yield even more significant results in the next 2 to 4 years.

5. Due to this research effort and to intensified spotted owl inventory, monitoring and evaluation programs, new information has become available since the Regional Guide was prepared which may be relevant to regional direction on spotted owl management. Direction in the R-6 Regional Guide was based on the recommendations of the Oregon-Washington Interagency Wildlife Committee, which were in turn based on the data and information about spotted owl populations and habitat needs which was available in 1980 (R-6 Regional Guide at p. 3-12). Four years of relatively intensive research, monitoring, and evaluation have ensued since that time.

DECISION

The Chief's decision is reversed and the R-6 Regional Guide and Environmental Impact Statement remanded to the Regional Forester for preparation of a Supplemental EIS which addresses the relevance of the biological information which has become available since 1980 and which adequately treats the issues hereinafter discussed under the direction hereby provided.

DIRECTION

The region should include in the Supplemental EIS a discussion of: (1) current knowledge as to the populations and habitat requirements of spotted owls in the Region, what evidence this knowledge is based on, and what contrary evidence exists; (2) the nature of the on-going research on habitat needs of spotted owls and the likely time that significant results from that research will become available; (3) the existing inventory of old growth and suitable spotted owl habitat on all ownerships in Region 6; (4) the inventory of old growth and suitable spotted owl habitat in national forest wilderness and other areas reserved from timber harvest in Region 6, such as federal and State park lands, as well as on lands on which timber harvest will be limited, including streamside protection areas, view zones, inoperable areas, and other federal, State, and private forest areas which are not likely to be managed intensively for timber production; (5) the current rate of reduction of old growth and suitable spotted owl habitat in Region 6 and projections as to the implications of this rate of reduction on the viability of the spotted owl on a regional level during the period of the initial Forest plans (10-15 years); (6) what is likely to be a minimum number of spotted owl pairs in Region 6

that would be needed to maintain the viability of the spotted owl in the Region; the acreage and distribution of suitable habitat that would be needed to support that number of pairs; how these numbers were arrived at; what uncertainties are involved; and how the various categories of federal, state and private lands might contribute to providing habitat for spotted owls; (7) how spotted owl habitat and populations outside Region 6 may contribute to spotted owl viability; (8) proposed plans for monitoring and evaluation related to spotted owls during implementation of the forest plans; and (9) the Regional Office's role in assuring the continued viability of the spotted owl in Region 6.

The Supplemental EIS should discuss a full range of alternatives including: (1) no further reduction in suitable spotted owl habitat on National Forest System lands in Region 6; (2) the number and size of spotted owl management areas proposed by Appellants in their letter of January 3, 1985; (3) the Oregon-Washington Interagency Wildlife Committee's recommendations of March 6, 1981; (4) an alternative proposing less than the Interagency Wildlife Committee's recommendations; and (5) no formal measures to protect the owl.

The Regional Guide and EIS should evaluate fully and disclose not only the biological and environmental implications of the alternatives, but the economic and social implications as well, e.g., changes in revenues to counties and the Treasury, effects on dependent communities and jobs, other community impacts, effects on regional timber supplies, opportunity costs (changes in the present net value of the forest) and other appropriate economic and social effects that are associated with alternative levels of spotted owl habitat protection.

The Forest Service is directed to make sure that standards for minimum management requirements designed to provide sufficient habitat to sustain the viability of spotted owls in Region 6 are developed in full recognition that uncertainty can be dealt with in a number of ways, including: (1) establishing an appropriate monitoring and evaluation program at the region and/or forest level which can form the basis for making adjustments in management practices either during the life of the plan, or at the time of plan revision; (2) recognizing that the only irretrievable commitments, if any, are those that result from management activities occurring during the period of the plan (rather than the entire 100+ year planning horizon), and that the 10-15 year periodic revision of forest plans will provide opportunities to make adjustments in MMRs based on the results of monitoring and the information and research which exists at that time; and (3) recognizing and identifying that on-going research targeted at answering specific questions may provide information by the time forest plans are revised. In addition, minimum management requirements for both the size and distribution of suitable habitat within the Region should be reviewed to assure that they are no more constraining that is necessary to maintain the continued viability of the spotted owl in the planning area (Region 6). It is again emphasized that planning alternatives providing for greater than these minimum levels are expected to be evaluated in the forest planning process.

The Forest Service is directed to review MMRs developed for other than spotted owls to ascertain that they are consistent with the principles described above.

In establishing MMRs, particular attention should be given to evaluating whether management activities proposed during the 10-15 year period of the plan are likely to limit the opportunity to make later adjustments in MMRs if subsequent research or monitoring indicates that additional protection is warranted. For example, if a particular national forest has a limited inventory of old growth forest and much of that could be harvested in the next 10-15 years, that fact should be taken into account in setting MMRs. If on the other hand, a national forest has an abundance of old-growth habitat, much of which will remain after 10-15 years, that fact also should be recognized when MMRs are established.

Any direction contained in the Regional Guide which allocates minimum numbers of spotted owls or spotted owl management areas to individual forests should be on a tentative basis only. Final decisions must await completion of forest plans, which will identify more precisely the available and suitable spotted owl habitat and be developed in the light of the biological information about spotted owl habitat needs which exists at that time. Forest planning must also take into account goals for other multiple-use objectives and the economic and other resource trade-offs associated with alternative levels of spotted owl habitat protection.

The R-6 Regional Office should have a continuing role in coordination to assure that adequate habitat is provided for by forest plans and that the latest information on spotted owl habitat needs is available to planning teams, so that the continued viability of the spotted owl in the Region can be provided for. The Regional Guide and EIS should discuss and outline this continuing Regional Office coordination role.

The Supplemental EIS should evaluate cumulative impacts and, if appropriate, include a worst case analysis.

Any reduction in the amount of suitable spotted owl habitat during the time necessary to prepare a Supplemental EIS will have an insignificant impact on the viability of the spotted owl. Therefore, Appellants' request for stay of issuance of timber sales in suitable spotted owl habitat is denied.

This decision constitutes the final decision of the Department of Agriculture as to all matters raised by this appeal.

Douglas W. MacCleery

DOUGLAS W. MacCLEERY
Deputy Assistant Secretary for
Natural Resources and Environment

IN RE: APPEAL OF REGION VI REGIONAL GUIDE AND EIS

Joint Statement of Reasons of the National Wildlife Federation, the Oregon Wildlife Federation, the Lane County Audubon Society, and the Oregon Natural Resources Council

and

Petition For Preparation of a Joint Agency Environmental Impact Statement

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This Statement of Reasons and Petition for Preparation of a Joint Agency EIS is submitted in support of Appellants' July 27, 1984, notice of appeal of the regional guide and EIS for Region VI of the Forest Service.

The appeal is based upon the failure of the regional guide and EIS to disclose and consider the cumulative and synergistic environmental impacts of timber harvesting in Region VI old growth areas, and particularly the effects of such harvesting on the Northern Spotted Owl (Strix Occidentalis Caurina). The failure of the regional guide and EIS to consider these impacts, to disclose uncertainties, and to use the best available information, has resulted in violations of the National Environmental Policy Act (NEPA), the National Forest Management Act (NFMA) and its implementing regulations, and the Sikes Act.

I. NEPA VIOLATIONS

Ranger districts in Region VI forests harvest timber on schedules established by five or seven-year "action plans."

Orig: FD&B
cc: Plan
cc: RF

Although these action plans determine where, when, and how much timber will be harvested, the ranger districts do not prepare NEPA reviews of the plans. See National Wildlife Federation v. United States, Civ. No. 83-1153-SO (D. Or. Aug. 6, 1984).[1/] Timber harvesting under these action plans causes cumulative environmental impacts, within forests and between forests. In the case of spotted owls, Region VI recognizes that harvesting of owl habitat in one forest affects owls on other forests. Despite this recognition, the Region has not (1) considered in an EIS the cumulative impacts of its harvesting in suitable owl habitat, (2) conducted research to fill data gaps and eliminate uncertainties regarding the impacts of its activities on spotted owls, or (3) considered the worst case possibilities of proceeding with its current harvesting activities in the face of inadequate knowledge about the effects of that harvesting.

A. Cumulative Impacts

The regional guide and EIS discuss Region VI's conclusions as to what factors should be considered in managing for spotted owls within individual forest plans, but do not consider the cumulative, regional impacts of such management. Yet NEPA clearly requires consideration of such cumulative impacts.[2/] See City

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1/ The BLM is currently harvesting timber pursuant to recently adopted District Plans. While each such plan was accompanied by an EIS, none of the documents discuss uncertainty or cumulative, regional impacts of planned harvesting on the spotted owl. An appeal of the BLM's failure to prepare an EIS examining cumulative, regional impacts is currently pending before the Interior Board of Land Appeals.

of Davis v. Coleman, 521 F.2d 661, 667 (9th Cir. 1975) (agency must consider impacts of development in areas accessed by a road, not just impacts of the road itself); Port of Astoria v. Hodel, 595 F.2d 467, 477 (9th Cir. 1979) (BPA must consider cumulative regional impacts of directing power customers to invest in thermal power production); Environmental Defense Fund v. Andrus, 596 F.2d 848 (9th Cir. 1979) (Interior must consider cumulative impacts of separate water contracts); 40 C.F.R. § 1508.27(b)(7) (an agency may not avoid preparing an EIS by "breaking [an action] down into small component parts."). The Forest Service's own regulations direct that: "Regional guides shall provide standards and guidelines for addressing major issues and management concerns which need to be considered at the regional level to facilitate forest planning."3/

Although individual ranger districts in Region VI forests are currently harvesting timber in suitable and occupied spotted owl habitat based upon five or seven year "action plans" to meet the Region's timber production goals, the effects of such harvesting on spotted owls have never been examined in an EIS. Some ranger districts have considered intra-district cumulative impacts in Unit Plans and EISs, but these do not examine extra-unit

2/ Cumulative, regional impacts have not been examined in existing unit plans and will not be examined in separate forest plans and EIS's.

3/ Although Region VI's guide was accompanied by an EIS, the EIS merely set forth the guide's standards without considering the potential consequences of implementing those standards. An EIS must do more than simply parrot the standards set out in the guide. It must discuss the effects of implementing those standards.

impacts or the cumulative regional impacts of old growth harvesting on spotted owls. Few of these Plans and EISs discuss spotted owls at all; none of them discuss cumulative regional impacts. Even forest plans, when they are completed, will not consider the regional impacts of old growth harvesting on spotted owls. And, although five year action plans implement regionally derived production goals, no attempt has been made at the regional level to assess the impacts of regionally determined harvesting goals. In short, old growth harvesting in a number of forests in Region VI is threatening the long-term viability of the northern spotted owl as a species, but no EIS has been prepared, either at the local or regional level, examining the cumulative effects of such harvesting. This violates NEPA.

B. Research and Worst Case Duties

There is substantial scientific uncertainty regarding the steps necessary to preserve the Northern Spotted Owl as a species. Region VI's own experts admit that they know little about what is necessary to preserve the owl as a species. The Forest Service and BLM do recognize the fact that the Northern Spotted Owl is dependent on old growth douglas fir for its habitat, and that cutting old growth at current rates threatens the survival of the owl as a species. The two agencies have therefore adopted a Spotted Owl Management Plan (SOMP) in an attempt to prevent the necessity of listing the owl as an endangered species under the Endangered Species Act. But the SOMP is based upon little more than a collective guess of several agency biolo-

gists as to what might be done to save the Northern Spotted Owl within the constraints of timber production goals. The SOMP was not prepared by experts in species viability nor were its proposals examined in an EIS.

The SOMP recognizes there is a lack of data to support the number of pairs of owls it predicts will be necessary to insure survival of the species. The data base for determining the minimum habitat acreage and dispersion ratio is also completely inadequate for making informed decisions.4/ As Region VI knows, when an agency proposes to proceed in the face of uncertainty, it must either conduct research to cure the uncertainty or, if the cost of doing research is exorbitant, prepare a worst case analysis. See 40 C.F.R. § 1502.22; Save Our ecoSystems v. Clark, Civ. No. 84-3887 (Ninth Circuit Jan. 24, 1984). In this case, there is admitted scientific uncertainty regarding the number of acres of old growth necessary to preserve breeding owl pairs, the number of pairs of owls necessary to maintain the species, and the proper dispersion necessary to maintain owls as a species. The Region must, therefore, either cure the uncertainty or

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4/ Region VI is in the process of conducting a research project on old growth ecosystems which should provide additional information (although perhaps not regional in nature) on the impacts of timber harvesting on such ecosystems. The problem is that Region VI is moving forward with old growth harvesting before it completes its research on the consequences of such harvesting. This violates NEPA. See Save Our ecoSystems v. Clark, No. 83-3887 (9th Cir. Jan. 27, 1984); 40 C.F.R. § 1506.1(a) ("no action concerning [a] proposal shall be taken which would (1) have an adverse environmental impact; or (2) limit the choice of reasonable alternatives" prior to completion of an EIS).

prepare a worst case analysis before it proceeds with timber harvesting in spotted owl habitat.

II. MINIMUM MANAGEMENT REQUIREMENTS

The National Forest Management Act (NFMA), 16 U.S.C. § 1604(g)(3) directs the Forest Service to adopt regulations "specifying guidelines for land management plans" which shall, among other goals, "provide for diversity of plant and animal communities." 16 U.S.C. § 1604(g)(3)(B). According to regulations implementing NFMA, a minimum requirement of Forest Service management is that diversity [defined as "the distribution and abundance of . . . animal communities and species" (36 C.F.R. § 219.3)], be preserved and enhanced. 36 C.F.R. § 219.27(g) (emphasis added). "Reductions in diversity of . . . animal communities . . . may be prescribed only where needed to meet overall multiple-use objectives." 36 C.F.R. § 219.27(g) (emphasis added). Region VI, in the Spotted Owl Management Plan (SOMP), the regional guide, and its timber harvest goals, proposes a significant reduction in Oregon's spotted owl population, without any showing of necessity. This violates 36 C.F.R. § 219.27(g).

Diversity is to be achieved by maintaining a "viable population of existing native . . . vertebrate species in . . . planning area[s]." 36 C.F.R. § 219.19. Maintenance of viable populations is another minimum requirement of Forest Service management. 36 C.F.R. § 219.27(a)(6). "In order to insure that viable population will be maintained, habitat must be provided to support, at least, a minimum number of reproductive individuals and

that habitat must be well distributed so that those individuals can interact with others in the planning area." 36 C.F.R. § 219.19. The Region VI guide and EIS violate 36 C.F.R. § 219.19 and § 219.27(a)(6) because the minimum management requirements (MMRs) for the spotted owl will not insure maintenance of viable populations of owls. A particularly glaring example of the inadequacy of the regional guide to satisfy the requirements of 36 C.F.R. § 219.19 is its failure to allocate owl pairs with proper dispersion between forests - something which may only be accomplished at the Regional level.

Regional and forest planning is to be undertaken by an interdisciplinary team, which must "integrate knowledge of the physical, biological, economic and social sciences." 36 C.F.R. § 219.5. Each Forest Supervisor is to "assure that the interdisciplinary team has access to the best available data" and that the data will be "evaluated for accuracy and effectiveness." 36 C.F.R. § 219.12(d). This requirement has its analogue in the regulations of the CEQ, which direct that "[a]gencies shall insure the professional integrity, including scientific integrity, of the discussions and analyses in environmental impact statements. 40 C.F.R. § 1502.24. The regional guide and EIS suggest several possible minimum management requirements for the Northern Spotted Owl, but these MMRs are based on inaccurate data or, in some cases, no data at all (although this is never disclosed). In this case, the use of available and more accurate data in spotted owl management would result in conclusions far different from those reached by the Forest Service.

For example, the guide assumes that the number of pairs identified in the SOMP (approximately 400) will be sufficient, if protected, to insure the survival of the species as a whole. But the number of pairs identified in the SOMP was based on a misapplication of the formula for determining population levels.

The guide states that, according to Dr. Soule, a census population of "500 breeding pairs (1,000 adult individuals) [will] maintain genetic integrity over time." (guide at D-6.) Actually, Dr. Soule's studies concluded that an effective population of 500 is necessary to guarantee long-term survival. The effective number of a population is defined as the size of an idealized population (with an equal sex-ratio, consistent reproductive rate, random breeding and constant population size) that would have the same amount of inbreeding as the population under consideration. The effective population number for any species is crucial to wildlife management plans because it serves as a base from which a sufficient census population can be determined. After accounting for (1) the variations of the actual population from the ideal population, and (2) environmental factors (fire, timber harvesting, isolation, etc.), the census population needed to maintain viability will be many times the effective population. As a result of confusing effective populations and census populations, the guide fails to insure the survival of viable populations of the spotted owl and violates 36 C.F.R. §§ 219.19, 219.27(a)(6), 219.27(g), and 40 C.F.R. § 1502.24.

Second, from the available data on habitat standards necessary to maintain an owl pair, the guide selects that data which will provide the least protection for the owl, and sometimes chooses a standard below that suggested by available studies. For example, the guide selects the observed minimum 1,000 old growth acres for a spotted owl pair's habitat. (guide at F-2.) The owl is known to be dependent on old-growth for its habitat, yet the guide does not guarantee that old-growth will be available as habitat. Instead, "capable" old-growth areas can be used. (guide at F-2.) The only published study which makes recommendations suggests that single pairs of owls be dispersed 5 to 8 miles apart and multiple pairs 8 to 12 miles apart; the guide selects the maximum 6 mile and 12 mile limits. (guide at F-2.) The guide provides for just enough "management areas" for 400 pairs, disregarding the risk of destruction to one or more areeas by environmental or man-caused elements. This "least-possible-protection" approach is inadequate to insure maintenance of viable populations of the spotted owl, even assuming the Region's original number of owl pairs is correct (it is not). The planner's claim that data is somewhat uncertain is all the more reason to err on the side of caution until further studies are completed.

The SOMP and regional guide are completely inadequate to insure maintenance of viable populations of the spotted owl and must be revised to reflect more current and accurate data.

III. SIKES ACT

The Sikes Act imposes upon the Forest Service a duty to "provide adequate protection for fish and wildlife officially classified as threatened or endangered pursuant to section 1533 of [the Endangered Species Act] or considered to be threatened, rare, or endangered by [a] State agency." 16 U.S.C. § 670h(c)(3)(D). This protection must be provided through the establishment of a comprehensive program "for the conservation and rehabilitation of wildlife, fish, and game [including] specific improvement projects and related activities and adequate protection for species of fish and wildlife, and plants considered threatened or endangered." 16 U.S.C. § 670g(a). The Northern Spotted Owl is considered by the Oregon Department of Fish and Wildlife and the Washington Department of Game to be a threatened species.

Neither the Forest Service nor the Bureau of Land Management have prepared the comprehensive plan and program required by the Sikes Act. In part because of this failure, each agency is in the process of violating its non-discretionary duty to provide "adequate protection" for the Northern Spotted Owl. 16 U.S.C. § 670h(c)(3)(D). The failure to consider the regional, cumulative, impacts of old growth harvesting on the spotted owl and arrive at a plan which will insure the survival of the owl as a species violates the Sikes Act.

IV. PETITION FOR JOINT AGENCY EIS AND RECONSIDERATION OF HARVESTING DECISIONS

Appellants hereby petition the Forest Service and the BLM for preparation of a joint agency EIS examining the cumulative, regional impacts of harvesting old growth timber in the Pacific Northwest. Such joint EISs are required by 40 C.F.R. §§ 1501.5 and 1506.2 whenever several agencies are "involved in a group of actions directly related to each other because of their functional interdependence or geographical proximity." 40 C.F.R. § 1501.5(a)(2). The BLM and Forest Service are required by the Sikes Act to coordinate their wildlife conservation efforts, and each has contributed to and adopted the Spotted Owl Management Plan (albeit each agency has its own interpretation of the SOMP). Quite apart from the SOMP and the obligations of the Sikes Act, the actions of each agency directly affect the actions of the other agency, and are functionally interdependent. Without proper management by each agency, the other agency's efforts to preserve the Northern Spotted Owl will necessarily fail. In such a case a joint agency EIS examining the cumulative impacts on spotted owls of the agencies' harvesting activities is required.

The Region has known for several years that the continued viability of the spotted owl and other old growth species needed analysis and decisions on a regional level. But it has yet to perform the kind of assessment required by NEPA. Since 1977, moreover, when the SOMP was first adopted, the agency (if it addressed the question at all) has relied on the SOMP to justify harvesting in "surplus" suitable spotted owl habitat.

The appellants raised many of the same issues presented here in 1980 in their original appeal of the SOMP. The Chief assumed, then, that all these issues would be handled in the regional plan (now the regional guide). Since then, however, timber sales have continued in suitable owl habitat, in reliance on the SOMP. It is now clear that the promised environmental review has been left out of the regional guide and its EIS.

Appellants must add to their demand for a regional EIS, therefore, a request for withdrawal and reconsideration of each five or seven year action plan, each unit plan and EIS, each BLM district plan and EIS, each timber management plan and EIS, and each timber sale and environmental assessment that authorizes harvesting of suitable spotted owl habitat. The Forest Service and BLM have a continuing duty to review and revise their decisions in light of new information. See Stop H-3 Associates v. Dole, 740 F.2d 1442, 1463 (9th Cir. 1984). There can no longer be any dispute that the harvesting of suitable spotted owl habitat raises very serious questions about the continued long-term viability of the owl species. These questions have never been addressed; continued old growth harvesting prior to the necessary environmental review can no longer be tolerated.

V. RELIEF REQUESTED

Appellants request that Region VI be directed to prepare a joint agency EIS, in conjunction with the BLM, examining the cumulative, regional impacts of old growth harvesting on the Northern Spotted Owl and other old growth dependent species.

Appellants request that Region VI be directed to conduct research to provide necessary data on the impacts of such harvesting or, if the costs of doing research are exorbitant, to prepare a worst case analysis of the consequences of proceeding in the face of uncertainty.

Appellants further request that Region VI be directed to immediately halt harvesting activities in areas of suitable spotted owl habitat, pending completion of an adequate EIS and compliance with 36 C.F.R. SS 219.19 and 219.27(a)(6).

Respectfully submitted,

Michael Axline
Counsel for
Lane County Audubon Society
Oregon Natural Resources Council

Terence Thatcher
Counsel for
National Wildlife Federation
Oregon Wildlife Federation

ON THE BRIEF
Nancy Bellerud
Saulius Mikalonis
Legal Interns

Dated this 18th day of October, 1984.

cc: William Leavell, Oregon Director, Bureau of Land Management
Robert Burford, Director, Bureau of Land Management

APPENDIX H

PROCEDURES TO CALCULATE HARVEST REDUCTIONS AND ECONOMIC AND EMPLOYMENT EFFECTS

INTRODUCTION

This Appendix defines the basis for calculating reductions in harvest and for all estimates of economic and employment effects. The most fundamental estimates are those of the harvest reductions that would result from the varying levels of protection for spotted owls in the Supplement alternatives. Most estimated employment and economic effects are calculated by multiplying the volume reduction by a constant; estimates of tax receipts also require additional calculations.

The general rationales for assuming linear relationships between harvest reductions and their effects are:

1. More sophisticated analyses are dependent upon complex models which require comprehensive data bases, but those data bases (especially for the Timber Assessment Market Model (TAMM) and Input/Output Model (IMPLAN) analytical models) are outdated, do not capture probable recent changes, and may yield misleading estimates.

2. Linear relationships make the analysis "transparent" and easily understood: if the reader wishes to use alternative assumptions, the consequences can be easily determined.

The weakness of this approach is that estimated effects are based on average, rather than marginal, relationships. Judgment suggests the effects of large-reduction alternatives, or at least of those with the largest reductions, are probably understated relative to the effects of the other alternatives.

Discussions in this Appendix include:

Estimating and validating National Forest harvest reductions.

Reductions in flows of National Forest logs to processing mills in substate areas.

Effects on employment and importance to substate areas.

Reductions in cash flows: management receipts and costs, payments to counties, and tax receipts.

Estimating and Validating National Forest Harvest Reductions

Individual Forest Planning Models (FORPLAN) served as the basis for calculating the reductions in timber harvest for each of the 13 National Forests where spotted owl habitat is an issue. Models of individual Forest Plan alternatives were not generally available. Therefore, each model used in this analysis was formulated as standard Benchmark 7. This benchmark maximizes present net value within limitations reflecting general agency policies such as nondeclining harvest flow at or below the long-term sustained yield capacity, rotation lengths generally no shorter than 95 percent of the age of culmination of mean annual increment, and meeting minimum legal requirements to protect basic resources.

Harvest reductions of the extremes and midpoints within the range of spotted owl habitat alternatives presented in this document were explicitly analyzed. (Other estimates were based upon interpolations.) These included no formal protection of owl habitat or Alternative A; 550 habitat areas at 1000 acres each; 1000 habitat areas at 2200 acres each; and no further reduction in suitable owl habitat or Alternative L. Differences in timber harvest levels were estimated by comparing computer runs with and without lands dedicated to owl habitat.

It had been found through detailed examinations of the no-change Alternative C on each National Forest that an average of about 80 percent of the required acreage fell on tentatively suitable lands. It was assumed in the present analysis this same proportion would hold for all alternatives. Although the validity of this assumption can only be determined through detailed Forest-level analysis of all alternatives, it is likely that habitat requirements of alternatives providing the higher levels of protection to the spotted owl will fall more heavily on suitable lands. This implies displayed reductions in harvest levels for such alternatives are probably underestimated relative to reductions in other alternatives.

To validate the estimates, the following question was addressed: do the estimates of reductions in harvest based on these benchmark analyses reasonably approximate the reductions in harvest and the relative differences among alternatives to be expected from analyzing individual Forest Plan alternatives?

The benchmark results were compared to the tradeoffs of increasing habitat area size from 1000 acres to 2200 acres in the context of draft plan alternatives that were available for several National Forests. Table H-1 displays information obtained from three National Forests. The middle column shows the total acres identified as being tentatively suited for timber production. The right-most column shows the marginal or additional opportunity cost of withdrawing one additional acre for spotted owl habitat (or for any other purpose), as measured in terms of first decade cubic feet of timber harvest foregone. As the suitable land base decreases on these forests, opportunity costs of additional reductions increase at an increasing rate.

Table H-1

Marginal Cost of Increasing Owl Habitats

Alternatives by Forest	Tentatively Suitable Land (M Acre)	Reduction in First Decade ASQ per Additional Acre of Habitat (MCF/Acre)
Gifford Pinchot		
Alt. D	889	0.912
Alt. J	774	1.223
Alt. L	448	1.278
Mt. Hood		
BM #7 Variation	624	1.032
SEIS Alt. D	608	1.044
BM #7 Variation	576	1.086
Tent. Forest Plan Alt.	531	1.196
Tent. Forest Plan Alt.	515	1.287
Alt. J	509	1.294
Alt. L	398	1.394
Willamette		
Alt. D	932	1.657
Alt. J	753	1.762
Alt. L	527	1.864

The opposite situation was found on the Siskiyou and the Mt. Baker-Snoqualmie National Forests. As the number of acres withdrawn for owl habitat increased, those additional acres supported less timber volume or lower timber values, or both. As a consequence, marginal opportunity costs tended to decrease rather than increase.

A different kind of comparison was also made. Several Forests independently estimated the impacts on harvest of increasing the number of acres per habitat area from 1000 to 2200, by examing tentative Plan alternatives. Table H-2 compares the results of the Supplement analysis with these estimates. The table generally supports the conclusion that there is little difference in the percent reductions of annual timber harvests.

Table H-2

Impacts on Timber Harvests of Increasing the Size of Owl Habitat Areas from 1000 to 2200 Acres

Forest	Supplement Impact	Forest Plan Impact
Mt. Baker-Snoqualmie	- 8.2%	-11%
Mt. Hood	- 8.8%	-6.8% 1/
Olympic	- 7.3%	-5 to -8%
Siskiyou	- 2.8%	- 5%
Siuslaw	-10.3%	-10%
Wenatchee	- 9.2%	-8.4% 1/

1/ Information based on FORPLAN analysis using tentative Plan alternatives. Other impacts based on Forest Staff estimates without explicit analysis through FORPLAN.

The evidence is mixed about the reasonableness of the absolute estimates of harvests foregone. The Forest Service believes Table H-1 portrays the situation on most forests: impacts are greatest when the starting point, the suitable land base, is smallest. Because the tentatively suitable land base in Benchmark 7 will always be larger than the suitable land base in multiple-use plan alternatives that are considered in detail (due to the greater number of analytical constraints responding to public issues and management concerns), increased habitat acreages will lead to larger reductions in harvests in Forest Plan alternatives. However, the comparisons in Table H-2 implies the opposite. Equal percentage decreases imply smaller reductions in plan alternatives, because they start with smaller timber-producing land bases.

There are other potential influences that can only be defined on a forest-by-forest basis. To an unknown extent, reservations of habitat areas will overlap or coincide with areas managed for other, nontimber purposes. This is particularly true in plan alternatives emphasizing relatively high levels of amenity production, where non-owl considerations may lead to, say, exceptionally long rotations for timber production. Under such circumstances, increasing owl habitat acres will have relatively small marginal effects.

On balance, estimates of absolute reductions in harvests appear reasonable, under the policy of non-declining yield, at least for the less-extreme reductions in harvest levels. This qualification is necessary because the evidence in Table H-1 suggests, as more-and-more protection is required, timber harvest reductions increase at an accelerating rate. Further, the constant assumption in all alternatives--drawn from the relatively low-impact Alternative C -- that 80 percent of habitat acreage will come from suitable lands probably understates the percentage for alternatives with the most stringent requirements. This means it is likely that reductions in harvest, and consequent economic and employment effects, are relatively underestimated in those instances. However, the appropriate adjustments can only be made by "fitting" habitat acreages outside

forest-specific FORPLAN models during the planning process on individual forests.

Table H-3

Percentage Distributions of 1982 Log Flows from National Forests With Spotted Owls to Survey Units[1/] [2/]

Washington Survey Units

National Forest	Puget Sound	Olympic Pennisula	Southwest Washington	Central Washington	Inland Empire
G. Pinchot	1.0%	33.0%	66.0%	-	-
Mt Bak-Snoq.	97.0%	-	-	3.0%	-
Okanogan	3.0%	-	-	73.0%	24.0%
Olympic	7.0%	93.0%	-	-	-
Wenatchee	5.0%	-	-	95.0%	-

Oregon Survey Units

National Forest	N. West Oregon	W. Central Oregon	S. West Oregon	Central Oregon	Blue Mountain
Deschutes	-	-	-	100.0%	-
Mt. Hood	71.0%	5.0%	-	24.0%	-
Rogue River	-	-	99.0%	1.0%	-
Siskiyou	-	2.0%	98.0%	-	-
Siuslaw	42.0%	51.0%	7.0%	-	-
Umpqua	-	19.0%	81.0%	-	-
Willamette	15.0%	84.0%	1.0%	-	-
Winema	-	73.0%	27.0%	-	-

1/ Sources: 1982 Washington Mill Survey: Wood Consumption and Mill Characteristics; Washington Mill Survey Series Report No. 8; 12/83; D. Larsen, L. Gee and D. A. Bearden; Dept. Nat. Res., Olympia, Washington. Oregon's Forest Products Industry: 1982; 10/84; J. O. Howard; Res. Bull. PNW-118, USDA Forest Service. PNW Forest and Range Experiment Station, Portland, Oregon

2/ Only minor volumes harvested on National Forests crossed state lines for processing.

Reductions in Flows of National Forest Logs to Processing Mills in Substate Areas

To estimate employment effects in substate areas, it is first necessary to estimate how the flow of logs to each area would be reduced under the various alternatives. Because of the possibility that individual mills might react to reduced harvests by changing the areas from which they purchase logs (logs have been moving over longer distances over time), substate areas were defined to be relatively large areas consisting of groups of counties. Each state was divided into five substate areas, called "survey units."

The following procedure was used to translate reductions in National Forest harvests into reductions in logs available for processing in these survey units.

1. All counties in the Region were grouped into survey units, identified in Tables H-5 and 6.

2. The percentages of logs flowing from each spotted owl forest to each survey unit are displayed in Table H-3. Distributions were based on mill studies performed in 1982. That year was not typical in terms of wood products production: total production was 11.2 billion board feet and only 2.8 billion board feet of National Forest logs were processed. However, probably because the survey units include such large geographic areas, the 1982 patterns of log flows were quite similar to those in 1976, a high production year. These patterns are not expected to change significantly during the planning period.

3. The estimated harvest volumes of the base Alternative A for each forest (displayed in Table 4-24) were "spread" across survey units using these percentages. These volumes were then totaled for each survey unit. This procedure was repeated to "spread" the reduced volumes of harvests estimated for representative Alternatives F, I, and L. The results were used to estimate consequent reductions in employment and in the discussion of community impacts in Chapter 4.

Effects on Employment and Importance to Substate Areas

In this document it is assumed that six private sector jobs will be directly associated, during the planning period, with each million board feet of timber that are harvested and processed domestically.

There has been a long-term trend of substitutions of capital for labor in the wood products industry. This has resulted, and probably will continue to result, in a gradual reduction of employment per unit of wood processed. However, there exists no comprehensive set of empirical data that permits projections of these labor-to-output ratios over the planning period with full confidence. The current assumption is based on fragmentary data developed in on-going studies of productivity (Wall and Oswald, 1975). (In general, increases in productivity were very rapid

during the 1950's and 1960's but slowed in the 1970's. It now appears the pace has picked up again in the 1980's, perhaps due to the general recession and timber-specific issues.)

Analyses using state-specific IMPLAN input-output models suggest there are also, on average, 2.71 "nondirect" jobs in Washington and 2.59 "nondirect" jobs in Oregon associated with each million board feet of timber. ("Nondirect" = "indirect" + "induced.") These "multipliers" would be smaller at the county or survey unit level and larger at the Regional level. (See below for income relationships and discussions of assumptions in the IMPLAN model.)

To assess the importance of harvest reductions to the economic viability of subareas of the Region, the excess employment technique was used to identify the industries comprising the economic base. This technique proceeds from the assumption that the national distribution of employment among industries is the norm. Any industry with employment in excess of this norm is considered to be producing for export markets outside the region and is part of the economic base. The percentage of excess employment accounted for by the forest products industry serves as an indicator of a local economy's "timber dependency." These estimates are reported in Tables H-5 and H-6. ("Survey units" are called "impact areas" in Chapter 4.)

Since this index does not account for self-employed workers in the forest products industry, it underestimates the relative importance of the forest products industry. The timber dependency index for much of Oregon has probably not changed much since 1980. Employment has increased a modest amount whereas agriculture, the state's second largest industry has been troubled by low crop and livestock prices. Furthermore, employment in high tech industries--a major component of the economic base in the Portland metropolitan area--has dropped since 1980. The timber dependency index for the Washington may be a little high since defense spending has increased relative to the rate of recovery of timber dependent employment.

Table H-4

Timber Dependency Indexes for Selected Oregon Counties, by Survey Units, 1980[1/]

Survey Unit	County	Dependency Index
Northwest Oregon	Tillamook	44.1
	Columbia	55.8
	Polk	29.7
	Clatsop	27.3
	Hood River	19.2
	Clackamas	15.5
	Yamhill	15.1
	Washington	8.2
	Marion	5.0
	Multnomah	0.4
Unit Average		10.1
West Central Oregon		
	Linn	41.9
	Lincoln	38.2
	Lane	25.1
	Benton	15.9
Unit Average		46.0
Southwest Oregon		
	Douglas	68.2
	Coos	62.1
	Curry	49.8
	Josephine	42.8
	Jackson	42.6
Unit Average		59.1
Central Eastern Oregon		
	Klamath	65.5
	Crook	55.7
	Deschutes	40.0
	Jefferson	32.0
	Lake	25.1
	Wasco	11.3
	Wheeler	5.1
Unit Average		48.2
State of Oregon		16.2

1/ Timber-dependent employment in the unlisted counties would not be affected by reductions in harvest to preserve spotted owl habitat. These counties are included in the Blue Mountain survey unit.

Table H-5

Timber Dependency Indexes for Washington Counties, by Survey Units, 1980[1/]

Survey Unit	County	Dependency Index
Puget Sound	Snohomish	27.0
	Whatcom	17.4
	Skagit	19.1
	Pierce	7.0
	San Juan	2.4
	King	.9
	Kitsap	.6
	Island	-
Unit Average		6.1
Olympic Peninsula		
	Grays Harbor	60.7
	Clallam	60.4
	Mason	52.5
	Lewis	52.0
	Pacific	41.3
	Jefferson	37.0
	Thurston	4.1
Unit Average		41.1
Southwestern Washington		
	Cowlitz	76.3
	Wahkiakum	50.1
	Clark	44.8
	Skamania	31.1
	Klickitat	26.5
Unit Average		59.1
Central Eastern Washington		
	Okanogan	16.5
	Kittitas	4.0
	Yakima	3.9
	Chelan	5.8
	Lincoln	.7
Unit Average		6.5
State of Washington		16.2

1/ Timber-dependent employment in the unlisted counties would not be affected significantly by reductions in harvests to preserve spotted owl habitat. These counties are included in the Inland Empire survey unit.

Reductions in Cash Flows: Management Receipts and Costs, Payments to Counties, and Tax Receipts.

National Forest Costs. An average Regional cost during the planning period of $27.22 per thousand board feet was estimated. This includes timber sale preparation, support by nontimber functions, appropriated road costs, and engineering design, maintenance and construction. This cost was multiplied by the reduced volumes for each forest in each alternative and totaled by alternative. To this was added cost-savings of $26,000 per Federal employee laid off. Reported reductions may over-estimate the savings of large reduction alternatives relative to those of more modest alternatives because use of a single cost per unit-volume does not allow possible increases in costs due to displacements of timber harvests to remote or less productive areas.

National Forest Timber Receipts. Average prices were projected for the planning period by species for each forest. Weighted average prices for western hemlock and Douglas-fir, the two major species providing spotted owl habitat, were calculated (Table H-6). These were multiplied by the reduced volumes estimated for each forest for each alternative and displayed in Chapter 2. Estimates relatively overstate decreases in receipts for large reduction alternatives because no adjustments are made for average market price increases in response to decreased Regional timber supplies; higher unit values for smaller harvest levels are not credited.

Table H-6

Average Weighted Prices for Western Hemlock and Douglas Fir and Purchaser Road Credits for the Planning Period[1/]

National Forest	Timber Receipts	Purchaser Road Credits
	------------ Dollars per MBF	-------------
Gifford Pinchot	172	20.70
Mt. Baker-Snoqualmie	171	13.70
Okanogan	105	6.44
Olympic	119	10.21
Wenatchee	103	8.32
Deschutes	155	1.89
Mt. Hood	181	9.79
Rogue River	171	9.88
Siskiyou	154	34.41
Siuslaw	194	12.97
Umpqua	164	18.29
Willamette	204	12.31
Winema	202	2.29

1/ Source: R-6 Planning Instructions

Payments to Counties. Average purchaser road credits per thousand board feet were projected for the planning period for each forest. These were added to the average timber receipts per thousand board feet, multiplied by the reduction in harvest estimated for each forest for each alternative, and divided by four. This resulted in estimates of the reductions in payments for each forest (Table H-6). These estimates were then totaled across forests for each alternative.

Distributions of these reductions in payments to the groups of counties within survey units were also calculated for representative alternatives, using the following procedure.

1. All counties in the Region were grouped into survey units, identified in Tables H-5 and 6.

Table H-7

Percent Distributions of Payments to Counties from National Forests with Spotted Owls to Survey Units, 1985

Washington Survey Unit

National Forest	Puget Sound	Olympic Pennisula	Southwest Washington	Central Washington	Inland Empire
G. Pinchot	-	30.0%	67.0%	3.0%	-
Mt Bak-Snoq.	75.0%	3.0%	-	22.0%	-
Okanogan	-	-	-	100.0%	-
Olympic	-	100.0%	-	-	-
Wenatchee	-	-	-	100.0	-

Oregon Survey Units

National Forest	N. West Oregon	W. Central Oregon	S. West Oregon	E. Central Oregon	Blue Mountain
Deschutes	-	-	-	100.0%	-
Mt. Hood	80.0%	-	-	20.0%	-
Rogue River[1/]	-	-	79.0%	12.0%	-
Siskiyou[1/]	-	-	96.0%	-	-
Siuslaw	19.0%	69.0%	12.0%	-	-
Umpqua	-	13.0%	87.0%	-	-
Willamette	8.0%	88.0%	3.0%	1.0%	-
Winema	-	-	-	100.0%	-

[1/] California counties received 9% of payments by the Rogue River and 4% of payments by the Siskiyou National Forests.

2. The percentage distribution of payments made by each forest with spotted owls to each survey unit was defined, based on actual distributions in 1985. These percentages are shown in Table H-7.

3. The reductions in payments by each forest calculated above were "spread" across survey units using these percentages for Alternatives F, I, and L. The results are shown in Chapter 4.

Tax Receipts. Estimated tax receipts include both state and Federal taxes paid by businesses and individuals. Information on current wages and tax payments was obtained from the states of Oregon and Washington and the Internal Revenue Service. Relationships among direct and nondirect individual and business taxes were derived from state-specific IMPLAN input-output models. This IMPLAN information was used to estimate all nondirect taxes and direct business federal taxes. To facilitate calculations of effects required for this document, where every effect must be related to exogenously defined reductions in timber harvest levels, all estimates were expressed as payments per direct employee in the forest products industry (FPI), including Standard Industrial Classification subsectors 2411, 2421, 2435, and 2436. Direct employees were "linked" to alternative harvest reduction levels through the assumptions that, on average, a reduction of a million board feet in harvest results in discharges of one Forest Service and six FPI employees. All estimates are summarized at the end of this section.

1. Relationships derived from IMPLAN input-output model -- economic relationships must be known to estimate nondirect employment and wages and all business incomes. It is also necessary to "adjust" model 1977 dollar flows to current dollar flows. (Note that changes in relative prices among economic sectors between 1977 and the years of the planning period might lead to misestimates.) "Property income," as defined in the IMPLAN model, was used as an estimate of net business income subject to tax.

Washington	Oregon	Definition
2.71	2.59	Nondirect jobs per direct job
(WA) 0.7174	(OA) 0.7200	Nondirect wages per dollar direct wages
(WB) 0.5306	(OB) 0.5255	Direct net business income per dollar direct wages
2.8	2.8	Nondirect net business income per dollar direct net business income

To adjust IMPLAN dollars to current dollars and for convenience in later calculations:

Current direct wage x Ratio			=		(Definition)
Washington - $24,922	(WA)	.7174	=	$17,879	Nondirect job wage
	(WB)	.5306	=	13,224	Direct net business income per direct job
Oregon - $24,118	(OA)	.7200	=	$17,365	Nondirect job wage
	(OB)	.5255	=	12,674	Direct net business income per direct job

2. Business tax payments. FPI business, affected by the "direct" effects of timber harvest reductions, and all other businesses, affected by "nondirect" (= indirect + induced) effects, are assumed to pay taxes at the same rates on average. This introduces an unknown error into estimates of nondirect taxes and a constant multiplier for state and federal taxes. Only "direct" business (or individual) taxes are included in any formal table in this document. Multipliers to determine nondirect taxes are also presented. Note that business net incomes and taxes are expressed as dollars per direct worker solely for analytical convenience. This does not imply that labor alone is viewed as the source of business income.

   a. Federal taxes. An estimated average effective tax rate for all FPI businesses of 29.25 percent of net income subject to taxes is used. This is based on the mean of the effective tax rates of ten major FPI firms. Using the IMPLAN information yields:

State	Direct Net Business income/direct job	Direct Business taxes/direct job
Washington	13,224	3,868
Oregon	12,674	3,707

   b. Washington taxes. Total business tax payments to the state by FPI firms in 1984 were:

$ 21,302,000	Business and occupation and transfer/sales tax
2,200,000	Levied on logging trucks
$ 23,502,000	Total

   These payments must be adjusted because they include taxes paid on logs that were exported rather than domestically processed, as required of logs from the National Forests. About 78 percent of total export volumes with a gross value of $546.7

million were harvested on FPI lands. Applying Washington's 0.5 percent business and occupation tax rate on gross income yields $2,734,000, an estimate of taxes paid on exported logs. The portion of all harvests that was exported, 38.9 percent, was used to reduce the tax on logging trucks. The adjusted estimates:

$ 23,502,000	Total FPI taxes
- 2,734,000	Business and occupation tax on exported logs
- 856,000	Logging truck tax on exported logs
$ 19,912,000	FPI taxes on domestically processed wood

Total FPI employment in 1984 can be adjusted in a similar fashion:

30,267	Total FPI employees
- 4,216	Loggers associated with exported logs
26,051	FPI employees associated with domestically processed wood

Dividing taxes paid by employment yields:

$764 direct business taxes per direct job

c. Oregon taxes. There are two major taxes levied on FPI firms. In 1984, receipts totaled about:

$ 2,000,000	General revenue, based on net business income
11,500,000	Highway funds, levied on logging trucks
$ 13,500,000	Total
- 920,000	Logging truck payments associated with exported logs
$ 12,580,000	FPI taxes associated with domestically processed wood

While logging truck payments were adjusted to account for the 8 percent of total harvest that was exported, it was not possible to adjust the general revenue payment because it is based on net, rather than gross, receipts; relationships between the two kinds of receipts are unknown. FPI employment was adjusted in a similar fashion:

52,195	Total FPI employment
- 1,027	Loggers associated with exported logs
51,168	FPI employment associated with domestically processed wood

Dividing adjusted taxes paid by adjusted employment yields:

$246 direct business taxes per direct job

3. Individual tax payments. Both the Federal government and the state of Oregon have progressive individual income taxes, requiring that average wages be estimated and tax tables consulted. (The following estimates are conservative: they assume taxes are paid on the basis of a single wage-earner with four exemptions.) In contrast, personal taxes in Washington are paid through a sales tax averaging 7.8 percent (state: 6.5 percent, county: 1.3 percent) on 35 percent of income. Forest Service wages are based on GS-7 salary; layoffs would generally range from GS-4 to GS-12. Average direct private sector wages are wages by FPI subsector weighted by number of employees.

State	Type	Wage	State Tax	Federal Tax
Washington	Direct, pvt. sec.	24,992	680	2,545
	Nondirect, pvt. sec.	17,879	488	1,311
	Forest Service	22,500	614	2,086
Oregon	Direct, pvt. sec.	24,118	1,475	2,377
	Nondirect, pvt. sec.	17,365	912	1,235
	Forest Service	22,500	1,320	2,086

To relate nondirect individual taxes to direct jobs:

State	Nondirect jobs per direct job	Nondirect tax per direct job: State	Nondirect tax per direct job: Federal
Washington	2.71	1,322	3,553
Oregon	2.59	2,362	3,199

4. Summary of tax payments.

Type	Source	Washington State	Washington Federal	Oregon State	Oregon Federal
		--------- Dollars per direct job ---------			
Direct	Forest Service	614	2,086	1,320	2,086
	Private sector job	680	2,545	1,475	2,377
	Business	764	3,868	246	3,707
	---- Ratio: Nondirect tax per dollar direct tax ----				
Nondirect	Private sector job	1.9	1.4	1.6	1.4
	Business	2.8	2.8	2.8	2.8

The differing ratios of nondirect to direct private sector individual payments reflect differences in both wages and tax rates. The initial assumption that all nondirect businesses pay at the same tax rate as the FPI direct businesses results in constant ratios.

The purpose of the preceeding calculations is to permit estimating the effects on tax receipts of reductions in National Forest harvest levels. Their reliability decreases as attention moves from direct to nondirect payments.

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